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THE CURRIE STORAGE BATTERY.

ABOUT this time last year we published an article from the pen of Mr. A. Reckenzaun on the secondary batteries shown at the Paris Exhibition. Among them was the Laurent-Cely accumulator, exploited and constructed by the Société Anonyme pour le Travail Electrique des Méteaux. The special feature of this invention consists in the nature of the active material, which is a mixture of chloride of lead and chloride of zinc. The fused chloride of lead has a density of 5·6 ; by incorporating chloride of zinc with it in certain proportions the density is reduced to 4·5. This mixture, brought to a state of fusion, is run into cast-iron moulds in the form of small buttons with rounded edges. When cool, the buttons are washed to remove the chloride of zinc, whereby a porous mass is obtained. Round these buttons is cast a frame of lead and antimony, when the plate is ready for formation. The negative plates are next placed in cells containing acidulated water, together with zinc electrodes, and charged. The hydrogen which is disengaged upon the positive electrode reduces the chloride of lead, and converts it into the metallic state.

A somewhat analogous process is used by Mr. Stanley C. C. Currie, of Philadelphia, and this is fully described in a recent number of the New York *Electrical Engineer*.

Commercial lead is first finely divided by a special process. This is dissolved in nitric acid and then precipitated as chloride of lead by the addition of hydrochloric acid. The white chloride of lead so obtained, after being thoroughly washed and dried, is mixed with a certain proportion of chloride of zinc and the mixture brought to a molten state in a furnace. The fused mixed chlorides are then poured into square moulds and allowed to cool. They are next placed into another mould prepared for their reception and a grid of lead cast around them, binding the blocks into a compact plate. The molten lead is forced around the blocks under pressure in order to ensure the best possible contact. The plates thus produced are then packed between zinc plates and placed into a tank containing a dilute solution of chloride of zinc. There is thus formed a voltaic couple, the action of which is to dissolve the zinc chloride and to extract the chlorine from the lead chloride, leaving spongy lead in its place. The last trace of chlorine is then removed from the plates by washing and then placing them in a tank containing nitric acid, and passing a current through them. The plates intended for anodes (positives) are formed into peroxide in dilute sulphuric acid.

The standard cell contains 9 positive and 10 negative plates, weighing together 34 lbs., and giving a capacity of 230 ampère hours ; the plates are $5\frac{3}{4}$ inches wide and 6 inches high.

The Germantown Electric Light Company, Philadelphia, uses 512 of these cells, arranged in 8 series of 64 each, having a combined capacity of 1,600 ampère-hours.

Mr. Currie has also designed several novel automatic devices used in connection with this storage battery plant. Among these is a "full-charge indicator," which consists of two strips of lead attached to a strip of ebonite. The upper ends of the lead strips carry a pair of binding screws and wires leading to an electric bell, whilst the lower ends of the lead are bent one over the other in such a manner as to leave a small air-space between them. The whole is suspended above the liquid of any cell. As soon as the battery is fully charged it begins to "boil," due to the rapid development of gases. This creates a spray of acid, which is projected upward, and some of it accumulates on the lead strips referred to until it forms a drop of liquid bridging the small gap between the two strips ; circuit is thus established for the bell to ring, and notify thereby the attendant that the charging is complete. This device is, however, used in connection with an automatic cut-out, constructed on the usual electro-magnetic principles. There is also an automatic apparatus for preventing reversals of polarity.

The Electric Car Company of America has been

testing Mr. Currie's storage batteries on four of their tramcars on the Lehigh Avenue Street Railway, Philadelphia, during the last four months. There are 100 cells, of the railroad type, on each vehicle. During the month of August 59,000 passengers were carried on this road, which has numerous curves and grades as heavy as 5½ per cent., whereby the batteries have been taxed to their utmost, the load on a car consisting, at times. of 100 passengers.

THE ELMORE PATENTS.

No. 10,720, 1884. This patent refers to the construction of moulds in segments, with suitable patterns engraved or embossed upon their inner surfaces, upon which copper or other metal is electro-deposited, and the resultant used as rollers for printing or embossing patterns either on paper or other substances.

No. 1,737, 1885, is an improvement in detail on the 1884 patent for segmental moulds which can be easily removed from the deposited metal and re-used. The purposes of such moulds are not limited to the production of printing rollers, as in the previous specification.

No. 4,499, 1885, is for a core or mould of a metal or alloy whose expansive or contracting properties shall differ from that of the metal deposited, thus facilitating its removal under proper treatment from the deposited metal. Also for the employment in the solution or bath of a burnisher. Three methods of burnishing are shown —by a travelling tool, by continuous pressure, and by an oscillating movement. The claims for the burnisher are limited to its application within the solution of the bath. The reason for this is plainly set forth in the patent in the following words :—

"It is well known that when almost any metal is deposited electrolytically from its solution the deposit is more or less crystalline, and that this crystalline nature of the deposited metal increases to a certain extent with the increased action of the current, therefore I employ the process of burnishing carried on simultaneously with the process of depositing, without removing the mandril with its deposit from the solution or out of a solution, and so the deposited surface is burnished without bringing it into contact with the air, and I carry on these two processes substantially as set forth."

No. 8,707, 1885, is for a system of making copper tubes by a combined electric and drawing process—that is to say, the preliminary formation of a block or "use" is by electro-deposition, this block being drawn down over a mandril through dies in the usual way ; also the particular process described for freeing the tube from its mandril ; and the manufacture of corrugated or spiral tubes by depositing the metal upon a core whose corrugations are of a screw-thread form, and this mandril, after a particular treatment described, can be withdrawn from the tube.

No. 10,451, 1885. This patent applies the burnishing principle to metal articles, such as pans, containers, and the like. It protects the combination of a rotating core with burnishers. The claims do not expressly submerge the burnishers, but the drawings do.

No. 11,800, 1885. This patent, an improvement on the four foregoing inventions, relates to a process for the deposition of copper in the manner described in previous patents, and for simultaneously refining impure copper, or extracting the metal from its ore. The economy of this is shown in the specification by the statement that the two things are done at "practically the same cost as would be incurred in carrying out either process separately."

No. 9,214, 1886. This patent applies the burnishing process to the covering of plates, wires, &c., or the deposition of metal into the form of sheets or bands. It introduces a revolving burnisher, and it claims the use of an endless band surface, or a continuous drum surface of lead coating or alloy, for receiving the initial deposit.

No. 16,637, 1887. This patent practically claims the obtaining long continuous bands from electrically-deposited copper by any suitable method.

No. 11,778, 1888. This patent provides for the application of a rolling or hammering action on the deposited coating during the process of deposition, instead of the burnishing. For this purpose the mandril has to be partially out of the solution, and a cover provided which ensures the return to the bath of any portions of the deposit which may be hammered off.

No. 12,022, 1888. This patent claims to protect the method of depositing copper at very high temperatures, and simultaneously submitting it to mechanical treatment. It is claimed that tubes made in this way will be more suitable for use as steam pipes, &c., than as commonly made.

No. 12,264, 1888. This patent refers to the moulds or cores, and claims to cover the use of a coating of lead or tin, for the double purpose of filling up any crevices which may exist in the main core, whether consisting of a single piece or a combination of separate pieces, and of preventing injurious action of the solution in the event of the core being of iron.

It is not our intention to comment on these patents in detail. It will be seen that some of them are not very nearly related to the main question, whilst others are of a subordinate character.

Each is doubtless an improvement in its respective sphere, and may be of considerable value, but does not control an industry. Attention has been rightly directed more particularly to the burnishing process, commencing with 4,499 of 1885, and the improvements on the original plan, or its application to different articles, which follow in later patents. It is necessary to draw a distinction between a patent which enables a certain thing to be done in one of several ways, and a patent protecting an article or a process which cannot be obtained in any other way. Electro-metallurgy is a science of respectable age. Electro-deposition is not new. Patents, therefore, on these subjects are necessarily restricted to the particular processes described. For example, the essence of the Elmore process is the combination of electrical deposition with

mechanical treatment; but the patents must be limited to a particular form of electro-deposition, combined with a particular form of mechanical treatment, and a monopoly can only exist on the assumption that no other forms are practicable.

Supposing the Elmore process to be a valuable invention it will, according to all precedent, meet with imitators. There is an unfortunate tendency on the part of a large number of people to have a hand in a revolution if they can. In such an event the Elmore Company would rightly fall back upon its patents for protection, proceeding against trespassers with all the rigour of the law. Assuming the novelty of the process they might reasonably claim, and, in our opinion, deserve, a "benevolent" construction; but when it is remembered that in 1885 (No. 4499) the mechanical treatment was considered to be essentially conducted within the solution and so protected in the form of burnishing, whilst in 1888 (No. 11,778) the mechanical treatment was found to be possible out of the solution, and so protected in the form of hammering, there seems to be little room even for a benevolent interpretation should some evil-disposed person take the burnisher of one patent and apply it in the manner reserved for hammering in the other.

Considering the amount of money paid for these patents, and the extensive financial developments to which they have given rise, it seems surprising to have to record that they have not yet received that *cachet* of validity—extensive work and immunity from attack, nor have they been through the fire of the Courts and come through unscathed.

THE ELECTRO-DEPOSITION OF COPPER.

IN last week's issue we referred to the various points involved in the electro-deposition of copper, and we laid before our readers certain details which were intended to enable them to form a more correct judgment on a certain process than had hitherto been possible except to the well-versed in electro-technical industries. We showed that in a German establishment the practical electro-deposition of copper involved an expenditure of 900 horse-power hours per ton, and that the daily output was 1,760 lbs. per day of twenty-four hours; approximately, about 5 tons per week of 144 hours.

In Dr. Hopkinson's report on the Elmore process, he estimates that with 60 tanks, working 161 hours a week, there will be produced 18,000 lbs. of tube, say 8 tons, and as our readers are already aware, the calculated cost of production did not exceed £5 per ton.

We have had several enquiries from the uninitiated public asking the meaning of Dr. Hopkinson's figures, for to some people it appears that the expression, "the net result of my observation is that a ton of copper can be deposited in steady continuous work by a consumption, with good engine and boiler, of less than 1½ tons of coal, costing 8s. 6d. per ton," gives rise to the belief that this is the total cost for motive power.

Now the output of the two establishments named is sufficiently close to enable a comparison to be made, so if we take 900 horse-power hours at even so low a rate as ½d. per horse-power, we arrive at a sum of, say, £2 for motive power alone, but this sum would probably be doubled in practice.

When it is borne in mind that the electrolytic method of refining copper is carried on in various places under totally different circumstances, and that it is not to the advantage of manufacturers to make public the details of their processes for securing the most economical results, it is evident that any published data in this connection, especially when merely hypothetical, must be received with caution; but the following figures, given by M. Fontaine, if not absolutely correct, have the advantage of being derived from actual practice:—

Factories taken as examples.	Expenditure per ton of refined copper.					
	Interest on capital.	Motive power.	Maintenance.	Labour.	General expenditure.	Total.
	Frs.	Frs.	Frs.	Frs.	Frs.	Frs.
Hilarion Roux, Marseilles	78.80	112.00	18	72.00	108.0	388.8
North German Refinery, Hamburg	64.65	39.50	12	40.0	40.0	196.0
Elliott Metal Co., Birmingham...	35.95	180.06	30	57.75	57.75	361.45

"The cost of fuel in Birmingham," says M. Fontaine, "is much lower than we have taken as a basis, but taking it at 5s. per ton at the works, we find that the motive power still costs 125 francs per ton of copper. If we leave the other figures unaltered, we obtain a total of 306·45 francs, that is to say, a much greater expenditure than at the Hamburg works. The interest on the capital engaged represents a small proportion only of the cost price, whereas at Hamburg it constitutes the main expenditure."

When we take into consideration the large amount of what may be briefly described as dead capital, the cost of production would have to be low indeed to allow of anything like the high dividends preshadowed in the prospectus of the various companies, especially when it is remembered that the process is a new one, in which a good deal may have to be learnt and paid for before even wire can be supplied commercially.

Dr. Hopkinson is probably correct so far as his estimate of fuel is concerned; but if the data given above represents the real expenditure entailed in electrolytic operations, then it looks as if his calculation of £5 per ton must be trebled.

We will now turn to another phase of the Elmore scheme.

Amongst the advantages claimed for this process is that "the electrical conductivity of the annealed copper has a conducting power of 4½ per cent. above that of the best guaranteed commercial copper." This statement has evidently been made upon the strength of the report of Messrs. Clarke, Forde and Taylor, an extract from which appeared in the various prospectuses of the

Elmore Copper Company that have been placed before the public on different occasions, and to which we have already alluded. They state, "your annealed copper has a conductivity of 4½ per cent. above that of the best commercial copper." Now, in the prospectus of Elmore's Patent Copper Depositing Company, Limited, the conductivity of the copper was, if we rightly remember, stated to be 102 per cent.; it would, therefore, appear that Messrs. Clarke, Forde and Taylor have based their calculations on commercial copper at 97½ per cent., which is, according to English manufacturers, a very fair basis. In France, however, the well-known firm of G. O. Mouchel, which owns perhaps the largest and oldest copper manufactory in France, has for some years paid special attention to the manufacture of copper wire for electrical purposes, and as far back as 1885 it was commercially supplying copper wires with a guaranteed conductivity of 100 per cent.

At the Inventions Exhibition, held in London in 1885, Messrs. Davis and Timmins, Limited, who were, and still are, the sole agents in England for Messrs. Mouchel, exhibited a large quantity of wire, guaranteeing the conductivity to be not less than 100 per cent., and the firm has since that date been supplying large quantities of similar wire with the same guarantee. We have been assured by Messrs. Davis and Timmins that, although they only guarantee 100 per cent., the bulk of the wire will be found considerably over this. At the official tests made at the International Exhibition of Antwerp in 1885, it was found that annealed commercial copper wire manufactured by G. O. Mouchel had a conductivity of 104·15 per cent., with an elongation of 40 to 60 per cent. From the above facts, it is evident that neither Messrs. Clarke, Forde and Taylor, nor the directors of the Elmore Company, were aware of what had been done in France as regards the conductivity of copper, and this appears all the more strange, as for the last five years Messrs. Davis and Timmins have been, as agents for G. O. Mouchel, constantly advertising.

In the usual contracts for copper wire for electrical purposes, a minimum of 96 per cent. conductivity is stipulated, and so long as this is the case, it would rather appear that, from a manufacturer's point of view, one would not feel inclined to pay a higher price for wire in order to ensure a higher conductivity; this being so, the fact of Elmore copper being stated as of a higher conductivity than the ordinary English wire would not necessarily command for it any advance in price over the present commercial copper.

Now the Elmore process for the manufacture of copper wire is, commercially speaking, untried, and it may be often noticed that what is originally claimed in prospectuses of companies put before the public, do not afterwards, in commercial practice, work out quite so well. On the other hand, at Mons. G. O. Mouchel's factory the manufacture of copper wire has been carried on commercially for some years on a very large scale. Therefore one can hardly admit the great advantages in high conductivity copper wire in which one would be led (or, rather, misled) to believe by the Elmore prospectus.

THE LANE-FOX PATENTS.

WE hear from several quarters that Mr. Lane-Fox and his associates are contemplating taking action against a number of people with regard to their using their dynamos, accumulators, and incandescent lamps in conjunction with each other. Also, that many of the persons who have been notified have been innocent purchasers of plant which they have installed for their own use, and who question the policy of individually contesting this action, seeing that the terms under which they may now compromise appear comparatively reasonable. We think, however, that the mere fact of licenses having been applied for and granted to the uninstructed public, is no evidence of the justice of the patentee's claims, and it would be far better to test the issue with those who are fully acquainted with the subject, and who would be able to defend themselves on the merits of the case *per se*. We are credibly informed that the licenses which have been granted to the Brush Company, for instance, were so granted in consequence of that company, when they relinquished the Lane-Fox patents, having retained the right of working under them, and they can in no way be construed as a recognition by the Brush Company of the pretensions put forth by Mr. Lane-Fox.

We also hear that Mr. Lane-Fox does not limit his claim to the use of a dynamo accumulator, and lamps running in parallel together with a practically constant potential, but likewise claims the use of a battery if charged separately and then discharged; and if a battery be charged from a dynamo, and then discharged, and the battery is employed for running two or more lamps at the same time, he considers that an infringement of his patents. If this be so, to our mind it is a perfect absurdity,—he might as well apply for a patent for the discharging of batteries for lighting purposes.

But apart from all this, we would call on the lighting public, who are, or may be, threatened, to ask Mr. Lane-Fox on what grounds he can pretend to the rights he claims, for we have evidence that incandescent lamps in the form of platimum wires or strips were operated from batteries as far back as 1859, by Prof. Moses G. Farmer, in Salem, Mass., and believe that the house can be shown to-day (or, at any rate, it was a few years since), with the wires remaining in it where these experiments were made and demonstrated, and pamphlets were published with accounts of this matter before the date of Mr. Lane-Fox's patent. Also, at the Paris Exhibition of 1877, the Planté battery was exhibited by Messrs. Breguet, and there one might have seen the combination of a hand Gramme machine charging a Planté accumulator, and discharging its current through incandescent platinum wires. We think there will be no difficulty in proving, from several sources, that that combination was publicly in operation at that exhibition, as well as M. Gaston Planté's laboratory, and at the show rooms of Messrs. Breguet, in Paris. We would therefore advise the public to hesitate before even paying a small acknowledgment of the patents to the Lane-Fox Association in order to save them-

selves trouble. And we would more strongly advise Mr. Lane-Fox and his friends not to commence their attack on the innocent customer for electrical plant, but to test their position with foemen worthy of their steel either in the courts, or, still better, by discussion among a certain number of men who could, at a much less cost, show that the claim for the discharge of a secondary battery through electrical incandescent lamps in parallel is preposterous and absurd.

The Supply of Rare Metals.

PERHAPS no epoch in the history of metallurgy has been so marked as that comprised within the last few years. That period has witnessed the development of the processes for producing aluminium and theconsequent great reduction in the price of that metal. This price, however, requires to be brought down to a still lower level before the manifold uses to which the material can be put become capable of great extension. Simultaneously with the reduction in price of aluminium has followed an increase in the price of platinum, a metal which to the chemist and electrician is invaluable. This increase in price has been such as to augment the value of the metal by three times what it was only a few years ago. How important a factor this is may be recognised by the fact that the cost of the platinum leading-in wire of an incandescent lamp is the largest single item involved in the cost of manufacture. How far workable platinum ores are distributed over the globe appears yet to be very imperfectly known, but a recent discovery at Colac, Australia, appears to show that there is hope that a fairly abundant supply of the metal may yet be forthcoming. It is stated in the *Ballarat Courier* that samples of the ore taken from the Otunz Ranges give a return of 1,120 oz. per ton, and that great excitement reigns in the district. Certain doubts have been cast upon the genuineness of the discovery, but it is to be hoped that there is something more than a grain of truth in the announcement.

Welcome Little Stranger.

NOBODY seems to have taken much notice of the announcement made three weeks ago, that Messrs. Swan, Sonnenschein were to publish for the first time on the 4th October, a new penny weekly paper entitled *Electricity*, the editor of which is to be Dr. Julius Maier. The new paper has not yet appeared, and on enquiry of the publishers it was ascertained that the journal would be born on the 15th November. There is, however, already a possessor of the title, for on Saturday, March 29th last, *Electricity*, a weekly newspaper and technical journal first saw the light of day. The publishers were Messrs. Hampton, Judd & Co., of 14, Duke Street, Adelphi, W.C. The second number appeared on April 5th, but after a fortnight's existence it fell into a decline and died. It had, however, been intended to resuscitate the deceased as a penny monthly paper, but the process of cremation had entirely destroyed its vitality and it has never, as far as we can ascertain, again seen daylight. Nevertheless, the fact of the previous existence of *Electricity* does not appear to have been known by the promoters of the new journal until quite recently, and this is the reason for the delay in its publication. We believe the question of copyright is now agitating the minds of the owners of the old and the publishers of the new *Electricity*.

An Electrical Collapse.

A SHORT time ago a monthly contemporary came out with a grand flourish of trumpets announcing that in consequence of the progress taking place in electrical applications, it would in future devote a portion of its valuable space to electrical matters. For a short time volts and ampères were thick in the air, while Mr. R. E. Crompton received polite attentions in the way of portraiture and otherwise. This was, however, too good to last. Whether it be that our contemporary has become frightened over electrical nomenclature, or whether it has exhausted its knowledge of the subject we of course do not know, but the peculiar fact remains that, while in one month's issue there was no electrical matter, a spasmodic attempt at revival in the current number has only resulted in a brief notice of Bristol's mining lamp, which is now a matter of ancient history.

Storage Battery Explosions.

THE explosion which took place on board Earl Poulett's steam yacht is by no means an isolated case, and our readers will recollect the explosion on one of the Barking Road cars, which shattered all the windows into fragments. Fortunately no one has ever been injured by such accidents, and we are inclined to think that, as a rule, the force of these explosions is not sufficiently great to do more than split the receptacles, although the noise accompanying the action is loud enough to affect even the strongest nerves. These explosions never occur when the cells are open at the top and used in a well-ventilated place. The batteries were actually on the yacht's deck, where there should be plenty of air to carry off any hydrogen gas developed by over-charging; but the boxes were provided with lids having only a small vent hole, thus preventing a ready escape of gas, which might have been just sufficiently mixed with atmospheric air to produce disastrous effects when Lord Poulett struck a wax match and accidentally ignited some of the escaping vapour, which speedily communicated heat to all the neighbouring cells, and probably exploded the whole series simultaneously. This incident caused much alarm; a daily paper states that "electricians could in no way account for it, as it had hitherto been thought that under no circumstances could gas be generated." Mr. Reckenzaun tells us that he experienced explosions with covered cells, having vent holes, as early as 1882, also at different periods since then, but that neither he nor any one else had been seriously hurt, and that a sufficient supply of air, cells completely sealed, or quite open at the top, will be an efficient safeguard against mishaps of this description. Overcharging of storage batteries must evolve hydrogen, which, if accumulated in a close atmosphere, will produce one of the most explosive compounds when ignited. We give amongst our "Notes" the description of this little mishap as the *Daily Telegraph* has it, but the reference to Earl Poulett's electricians is utterly absurd. His technical adviser knows perfectly well that under certain conditions such mishaps as the one under notice may occur, and the remarks of our gaseous contemporary are therefore quite uncalled for. It is more than probable that as the incident occurred some two months ago the memory of the narrator of this pretty story is at fault, but nevertheless we may point a moral to adorn the tale: never allow these gases to accumulate, and don't search for free hydrogen with a lighted match.

THE FALL OF POTENTIAL AT THE CATHODE IN GEISSLER'S TUBES.

IT has been observed by E. Warburg that whilst in a Geissler tube filled with slightly moist nitrogen the difference of potential between the cathode and a point in the extreme visible limit of the negative glow remained constant, yet when the nitrogen is quite dry a considerable increase of fall takes place as the current passes [*vide* Gilbert's "Annalen der Physik und Chemie," series [2] Vol. XXI., page 545].

This observation has recently been under investigation again, and Warburg now attributes the phenomena to the presence of minute quantities of oxygen in the nitrogen, and shows in a paper in Gilbert's "Annalen," &c., series [2], Vol. XL., page 1, how these traces of oxygen may be removed. Sodium had previously been used for this purpose, but a difficulty was experienced in obtaining this metal in a state of sufficient purity.

Warburg now liberates his sodium within the closed tube in a nascent state by electrolysis through the glass, a portion of the tube being immersed in half per cent. sodium amalgam connected with the negative pole of a battery and heated to 300° C., the cathode of the tube being connected with the positive pole. When the last trace of oxygen has been removed a deep yellow light appears in the part of the tube where the sodium is liberated.

Nitrogen at 2·3 mm. pressure was freed from oxygen in 20 minutes with a current from three Bunsen cells connected with an induction coil capable of giving a 25 mm. spark in air, and making 390 contacts per minute. The excess of sodium was afterwards distilled into a remote portion of the tube. From his experiments Warburg gets the following mean numbers for the fall of the cathode in volts :—

Platinum cathode	in	nitrogen	= 232 volts.
„	„	hydrogen	= 300 „
Magnesium	„	nitrogen	= 207 „
„	„	hydrogen	= 168 „

Variations of a few per cent. still remain, but the author is of opinion that in perfectly pure gases the fall is independent of the current strength and of the pressure, being determined only by the chemical nature of the gas and of the cathode, and by the physical condition of the latter.

THE ACTION OF THE ELECTRIC ARC ON GASEOUS SUBSTANCES AND ITS EMPLOYMENT FOR DEMONSTRATIONS.

THE action of electricity upon various simple and compound gases has, as our readers well know, engaged the attention of physicists and chemists for many years. A few weeks ago we gave some account of an investigation into the behaviour of certain gases under the influence of the silent discharge [*vide* this paper, September 19th, 1890]. We have now to call attention to some recent work by a German scientist, namely, Herr B. Lepsius.

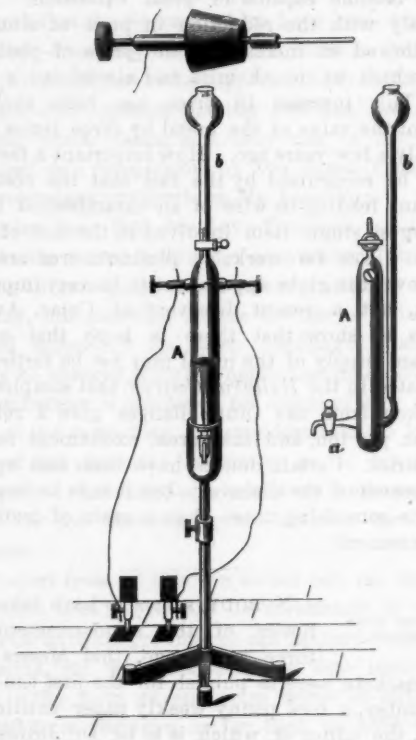
Lepsius has been studying the action of the electric arc on certain gaseous substances. During the course of his work he has designed an exceedingly interesting apparatus, which can be successfully employed for demonstrating the volumetric composition of various gases. The law of combination of gaseous elements and compounds by volume, which was enunciated in 1808 by Gay-Lussac, has not yet been subjected to as rigorous an examination as that which the laws of combination by weight have undergone.

The laws of chemical combination, in so far as they concern the gaseous elements, may be summed up in the following statement: "The gaseous elements combine in the ratios of their combining volumes, or in ratios which bear a simple relation to these." By combining volume, is here meant the smallest volume of a gaseous element which combines with unit volume of some specified gaseous element taken as a standard. The laws of "combining weights" have been amply verified by accurate experiments; but the laws of "combining volumes" does not stand on so firm an experimental basis.

It is evident, from what is stated in the preceding paragraph, that there is room, if not a demand, for improved methods and apparatus which shall be useful in studying the volumetric composition of gases.

There is already existing a form of apparatus invented by Hofmann, by means of which much good work has been done, but there are certain objections to it; for instance, it can deal only with small quantities of gas, and then the experiment takes a considerable time.

Lepsius's new apparatus depends for its efficiency upon the action of the electric arc. The accompanying sketch gives a very fair view of it. The essential features may be thus described.



A glass tube, A, 40 mm. in diameter and 300 mm. in length, is provided at its upper extremity with a glass stop-cock, and, 40 mm. below the stop-cock, with two lateral tubes, 15 mm. in length and 15 mm. in diameter; it is closed below, but provided with a stop-cock, *a*, and an upright tube, *b*, 10 mm. in diameter, as shown in the figure, the whole being placed on a suitable support. The lateral tubes serve for the introduction of the carbon poles, which are about 2 mm. in diameter (or larger if required), and enclosed in metal necks 12 mm. in length, which on the other side fit on the pin (2 mm. in diameter) of a copper rod (6 mm. in diameter), provided with a binding screw.

The metal necks are made of iron or of brass—in the latter case they must be lacquered—and are slit down on one side. The copper rods are fitted tightly into the lateral tubes by means of India-rubber corks, and are of such a length that they overlap each other about 10 mm., the corks being placed eccentrically in the tubes in such a manner that the rods can be brought into contact by slight pressure on one of the binding screws.

A potential difference of 30 to 50 volts is sufficient to give the necessary arc, but it is better to employ, say 60 to 80 volts, and a rheostat; the heat of the arc can then be regulated, so that the glass apparatus and the India-rubber corks are not damaged.

The gas is introduced in the usual way by first filling the apparatus with mercury.

Those who have ever been called upon to lecture before the public or a number of students, and have wished to demonstrate in an intelligible way the volumetric composition of gases, have probably been much inconvenienced by the insufficiency of the commonly known methods for this purpose. Lepsius' new apparatus, which of course is not patented, but may be the common property of all students of science, will, as the advertisements say, "supply a long felt want" in this direction, and, moreover, will prove of the greatest value in demonstrating the truth of certain hypotheses, and in placing the laws of combination by volume upon a sound experimental basis.

The following examples will serve to illustrate the use of the apparatus :—

Conversion of Carbonic Anhydride into Carbonic Oxide.—From 80 or 100 cc. of well dried carbonic anhydride is introduced into the apparatus, its volume measured under the atmospheric pressure, is marked on the tube, and the arc is ignited. Decomposition takes place with a brilliant light, and the volume immediately increases ; in about a minute decomposition is complete, and after a short time the temperature is sufficiently equalised to allow of the measurement of the carbonic oxide, the volume of which is found to be double that of the carbonic anhydride employed.

Conversion of Oxygen into Carbonic Oxide.—About 100 cc. of well dried oxygen is introduced into the apparatus, its volume is noted and the arc ignited ; the volume increases continuously, and in one or two minutes the oxygen is completely converted into double its volume of carbonic oxide.

The volume relationship between oxygen, carbonic oxide and carbonic anhydride can be conveniently and quickly demonstrated with a modified form of apparatus, a diagram of which is given in the original paper by Lepsius [*vide* "Berichte der deutschen Chemischen Gesellschaft, Vol. xxiii].

Conversion of Sulphurous Anhydride into Carbonic Oxide.—About 80 cc. of dry sulphurous anhydride is introduced into the tube A, shown in the figure ; the volume is measured under atmospheric pressure, and the arc is ignited ; the carbon burns with a beautiful blue light, the apparatus becoming filled with white fumes ; the volume of the gas increases, and reaches a maximum in about 30 or 40 seconds. On measuring the volume of carbon monoxide produced, it is found to be double that of the sulphurous anhydride employed.

That acetylene contains its own volume of hydrogen can also be demonstrated by means of the apparatus shown in the diagram.

This apparatus can be conveniently used for showing means of the electric arc. For this purpose a flask, 15 the formation of water-gas when decomposing steam by to 20 cm. in diameter, is provided with two lateral tubes, through which pass the carbon poles, arranged and adjusted as described above ; the mouth of the flask is closed with a cork, through which pass two glass conducting tubes, one reaching almost to the carbon, the other just passing through the cork ; the flask is inverted on a stand, and steam is passed in through the longer tube.

As soon as the air is completely expelled, the escaping steam is led under an inverted cylinder full of cold water ; if now the arc be ignited, a rapid evolution of gas, consisting of equal volumes of hydrogen and carbonic oxide, is observed.

The same apparatus can be used for showing the formation of water gas from water. The flask, provided with a single delivery tube, is filled with water, placed in an upright position, and a strong current passed ; the carbons become white hot, and a mixture of hydrogen and carbonic oxide is rapidly evolved.

THE ELECTRIC LIGHTING OF MONACO.

[FROM A CORRESPONDENT.]

IN the beautiful but notorious sea-bathing and gambling town, Monte Carlo, a central station for the electric lighting of the town is in course of erection, and is to be shortly brought into play. The concession for this undertaking was granted in February last to the firm of Lombard-Gerin & Co., of Lyons, by the Government of the Duchy of Monaco, for the entire territory of the state. Thereupon the above firm founded a company for carrying out the concession under the style Société Monegasque d'Electricité, having its registered office at Monaco. This company, which was constituted with the co-operation and participation of the Société des Bains de Mer et du Cercle des Etrangers at Monaco, is erecting and otherwise carrying out the above-named electrical works.

The concession for this undertaking was granted on very favourable conditions. For the edification of other projectors, I will recapitulate the more important stipulations.

Article 2 of the concession secures to the company the exclusive right to utilise the public domains of Monaco for laying down leads, underground or aerial, for the distribution of electric currents, whether for lighting or for the transmission of power.

This exclusive right, however, does not interfere with the existing rights of the Société des Bains de Mer, which had previously obtained a concession for laying electric leads for lighting the buildings which are at present its property.

Article 4 fixes the duration of the concession at 50 years, but after the expiry of 25 years the Government may cause the concessionaries to adopt any new means for the more rational distribution of the electric current if they have been found satisfactory in practice.

Article 6 provides for the reversion of the entire conductive network to the town of Monaco after the expiry of the concession. The buildings and the internal plant of the central station remain the property of the company ; but the town has the right to purchase them at a price to be judicially determined.

Article 7 gives the concessionaries the right to use the Zipernowsky-Déri-Bláthy system of distributing the current by means of alternating current transformers. The primary tension must not exceed 3,000 volts, and 120 volts is fixed as the limit for the secondary E.M.F.

Article 12 prohibits the use of the earth for the return current. The underground cables must have a single or, if needful, a double lead coating, unless they are laid in wooden boxes or earthen pipes, protected with metal sheathing. The joints for connection and distribution must be fixed in cast iron boxes carefully insulated.

Article 16 binds the projectors to supply current to every subscriber within the line of the streets traversed by the leads. To subscribers beyond such streets, current can be supplied only on condition that they undertake the entire cost of the connection from the nearest point of the conductive network.

Article 17 binds the company in all cases to lay at their own cost the primary conductor for the electric lighting of the ducal palace and the palace of the Governor, and to supply the necessary transformers. The expense of the secondary conductors and the internal fittings in these buildings fall upon the government. In return for the grant of the concession, the projectors are required to supply yearly, without charge, sufficient current for 50,000 10-candle glow-lamp hours of burning, whilst the Government is to pay for any current in excess of this quantity at the figure required from the most favoured consumer.

Article 18. The Government places the ground necessary for the erection of the works at the disposal of the projectors gratuitously for the total duration of the concession.

The work is already in full progress. Two alter-

nating current machines of the Zipernowsky type A_6 (each of 80,000 watts), together with the necessary exciters and transformers, are already set up, and a third machine will shortly be added.

The entire materials for this central station (both the motors and the electrical machines and apparatus) are being supplied by the firm Schneider & Co., of Creusot.

PASCHEN'S RESEARCHES ON POLARISED MERCURY.

STUDENTS of electricity are familiar with the common laboratory experiment of putting a drop of mercury in some dilute sulphuric acid which contains a trace of chromic acid, and then so fixing the end of a piece of bright iron wire that it dips in the acid, and at the same time just touches the edge of the mercury; under these circumstances, the wire commences a series of regular vibrations which may last for hours.

The usual explanation of these interesting phenomena is as follows: An iron mercury couple is formed when the piece of wire first touches the edges of the globule of mercury; the effect of this is that the surface of the mercury becomes polarised by a thin layer of hydrogen gas, the surface tension of the mercury is consequently increased, the globule becomes more convex, and contact with the iron is for the moment broken. The chromic acid now comes into play, the mercury is depolarised, and the original "flattened-globular" form is restored; the couple is thus formed again, and the same phenomena are repeated and a vibratory movement ensues.

The above experiment, owing to its remarkable character, attracted the attention of the leading electricians of the day when it was first discovered, but its true significance was scarcely appreciated until Lippmann began to work upon it. Lippmann, during the course of his investigation, was led to some experimental results which have demonstrated a marked relation between electrical and capillary phenomena.

One of the most important results accruing from Lippmann's work on those phenomena was the construction of his capillary electrometer. Few readers of this paper probably require to be enlightened upon the subject of Lippmann's capillary electrometer, and detailed description of it may be read in any good textbook. It can estimate very small electromotive forces, and as its electrical capacity is very small, it can show rapid changes of potential. It is not generally recommended for greater electromotive forces than 0·6 of a Daniell.

A short time ago F. Paschen published a paper in "Gilbert's Annalen der Physik und Chemie" (*vide* Series [2], Vol. XXXIX., page 43), in which he discussed the variations which take place in the surface tension of polarised mercury in different electrolytes. In the course of the researches described in this paper Paschen states that he found Lippmann's capillary electrometer, whilst yielding excellent results for electromotive forces of less than 0·9 volt, was quite untrustworthy for values above this limit, on account of the polarisation caused by the liberation of hydrogen gas at the meniscus.

Since Lippmann's electrometer is thus found unreliable, Paschen employed a simple apparatus which, though not so delicate, can be used for large electromotive forces. It consists essentially as follows:—An open U-tube is taken, having one limb about 24 mm. in diameter, whilst the other is somewhat shorter, and only 3 mm. in diameter. The tube is so far filled with mercury that the meniscus reaches the top of the narrow limb. The whole is immersed upright in a beaker containing dilute sulphuric acid and a layer of mercury, so that the meniscus in the shorter limb alone is below the surface of the liquid. Connection is made with the meniscus through the wide limb.

By means of this instrument Paschen investigated the change of surface-tension of mercury occasioned by polarisation in solutions of sulphuric acid, hydrochloric acid, sodium hydroxide, and various salts. He found that all changes of surface tension take place between the limits of + 0·1 and − 2 Daniell, and in the original paper curves are given which show that up to the maximum it is the anion that exerts the decisive influence, whilst beyond the maximum it is the cathion. The position of the two characteristic points of the curves, the maximum and the point where the electrolysis becomes evident, would appear to depend greatly on the concentration of the electrolytes.

In Lippmann's electrometer, and in Paschen's instrument also, the polarisation seems to be entirely at the meniscus and not at the large anodic surface. When the polarisation attains a constant value the surface-tension also becomes constant.

Temperature influences the results slightly, but not to such an extent as to interfere with the accurate working of the instrument under ordinary conditions.

Since these results were published Paschen has been continuing his researches upon the surface-tension of polarised mercury, specially considering the effect of concentrating the electrolytic solution and seeking to test Pellat's relation between the maximum of surface tension and the point where electrolysis begins.

An account of these experiments may be read in Gilbert's "Annalen der Physic und Chemie," series [2], vol. XL., p. 36.

For sulphuric and hydrochloric acids Paschen found that the maximum increases with increasing concentration, whilst the electromotive force for incipient electrolysis diminishes. It thus happens that for a definite mean concentration the two values become equal, so that it is only for this concentration that Pellat's relation holds good.

The fall beyond the maximum depends on the relative values of the electromotive force for maximum surface tension and for electrolysis. There is little or no fall for strong solution of hydrochloric and sulphuric acid, when the electromotive for electrolysis is far below the maximum.

Other electrolytes investigated by Paschen were solutions of nitric acid, ferrous sulphate, potassium hydroxide, potassium iodide and mercuric cyanide. Nitric acid and ferrous sulphate behave very similarly to hydrochloric acid.

The point for electrolysis is affected by the nature of the solvent. A strong solution of potassium cyanide behaves abnormally, giving a deflection of the meniscus in a direction opposite to that when other electrolytes are employed.

Experiments have also been carried on by Paschen with the so-called Wood's metal used instead of mercury, but the results have been identical in character.

NEWSPAPER OFFICE ELECTRIC LIGHTING.

THE electric light installation for the new offices of the *Bolton Evening News* has just been completed by Messrs. Ernest Scott & Co., Close Works, Newcastle-on-Tyne, electrical and general engineers.

The installation is said to be one of the most complete, if not the most complete, in Lancashire, and lights the entire premises. The arrangement of lamps is as follows:—

Basement	46	lamps of	16 candle-power
Ground Floor ...	58	„	„
First Floor ...	127	„	„
Offices	45	„	„
Entrance	1	„	200 „
Manager's Office ...	1	„	100 „

The whole of the lights throughout the building, with the exception of the offices, are pendants, and each lamp is fitted with a switch, secured to the pendant, so that every lamp in the installation can be switched on or off in the same way as gas.

There are two dynamos to drive the installation of Messrs. Ernest Scott & Co.'s standard "Tyne" type. Each machine is constructed to give an output of from 90 to 100 ampères at an electromotive force of 105 volts, the speed of each machine being 900 revolutions per minute.

As gas engines are used as the motive power for driving this installation, each dynamo has been fitted with a very heavy turned flywheel, supported on an outer bearing, and it has been found that the lights are perfectly steady, which is a result not very often obtained with gas engines unless special precautions are taken.

The current from these dynamos is taken to a main switchboard of a very handsome and massive description. The switchboard consists of an enamelled slate slab, about 5 feet long by 4 feet wide, and is fitted with two of Messrs. Ernest Scott & Co.'s improved coupling switches for connecting the two dynamos in parallel. Four double main switches, with fusible cut-outs on both positive and negative poles, are also mounted on the main switchboard. These switches are used to control the four departments, *i.e.*, basement, ground floor, first floor, and office.

Measuring instruments are also mounted upon the main switchboard, and by simply pressing the key, the pressure and quantity of current can be instantly measured. The enamelled slate base is mounted in a deep oak frame.

The office fittings are extremely handsome, and consist of five polished brass pedestals for the counters, eight polished brass brackets for the desks, one pendant with cut glass globe for the main entrance, containing a 200 C.P. lamp, and a pendant containing one 100-C.P. lamp for the manager's office.

This installation has now been running for some time without a hitch of any kind, and has given every satisfaction.

Messrs. Bradshaw and Gass, of Bolton, are the architects for the new buildings, and have throughout superintended the electric lighting arrangements, and much credit is due to them for the care and attention they have bestowed upon this matter.

INFLUENCE OF ELECTRIC TENSION ON THE INSULATION OF CABLES.*

By A. PALAZ.

THE importance of a good insulation of electric leads grows continually greater, especially since the use of high tension currents becomes more and more general, the rather because the insulation decreases in proportion as the tension of the current increases. This fact was first mentioned by Herr Uppenborn.

The exact determination of the variations of the insulation with the tension of the current presents the greater interest as it enables us to determine if a cable has a tendency to modify the nature of its insulating material in consequence of the prolonged passage of a high-tension current.

La Lumière Electrique has recently summed up the measurements of Herr Fordenreuther relative to the determination of the insulation of electric conductors, in the course of which this physicist has incidentally touched upon the question which forms the subject of the present memoir. But this question has quite recently been studied in a thorough manner by Herr C. Heim, of Hanover, who has published his results in the last numbers of the *Electrotechnische Zeitschrift*.

The measurements of Herr Heim have reference to two cables coated with lead and insulated with jute saturated with resin or a mixture of different waxes, as also upon a core insulated with gutta percha. They have been effected by the aid of the ordinary method which consists in measuring the leakage by means of a very sensitive Thomson's galvanometer.

* *La Lumière Electrique.*

Core insulated with gutta-percha.

Duration of electrification in minutes.	Number of measurements.	Ratio of potentials in volts. $\frac{50}{460}$	Ratio of potentials in volts. $\frac{50}{208}$
1	1	4·8 per cent.	...
2	...	5·4 „	...
1	2	4·6 „	...
2	...	5·0 „	...
1	3	10·6 „	2·4 per cent.
2	...	10·9 „	2·3 „
1	4	8·5 „	1·0 „
2	...	6·7 „	...
1	5	6·8 „	...
2	...	7·9 „	...
1	6	6·6 „	...
2	...	8·1 „	...
1	7	5·7 „	...
2	...	6·2 „	...
1	8	5·3 „	...
2	...	6·7 „	...
1	Mean	6·6 per cent.	2·0 per cent.
2		7·1 „	2·2 „

Cable coated with Lead, No. I.

Number of Determinations.	Ratio of potentials in volts. $\frac{50}{460}$	Ratio of potentials in volts. $\frac{50}{208}$	Ratio of potentials in volts. $\frac{91}{460}$	Ratio of potentials in volts. $\frac{91}{208}$
1	3·3 per cent.	0·77 per cent.	...	...
	2·8 „	0·80 „	...	...
2	2·3 „	0·47 „	...	...
	2·0 „	0·56 „	...	...
3	2·4 „	0·47 „	...	...
	2·1 „	0·75 „	...	...
4	...	...	3·3 per cent.	2·4 per cent.
	...	...	3·7 „	2·8 „
5	3·8 „	1·6 „	4·3 „	2·2 „
	3·8 „	2·5 „	3·8 „	2·5 „
Mean	2·9 per cent.	0·81 per cent.	3·8 per cent.	2·3 per cent.
	2·7 „	1·15 „	3·8 „	2·7 „

Cable coated with Lead, No. II.

Number of Determinations.	Ratio of potentials in volts. $\frac{50}{460}$	Ratio of potentials in volts. $\frac{50}{208}$	Ratio of potentials in volts. $\frac{104}{460}$
1	2·2 per cent.	...	...
	9·0 „	...	...
2	8·1 „	4·4 per cent.	6·0 per cent.
	10·0 „	8·1 „	4·4 „
3	...	...	3·6 „
	...	...	5·5 „
4	...	...	3·4 „
	...	...	6·1 „
5	3·5 „	...	2·3 „
	4·1 „	...	...
6	7·5 „	3·0 „	6·0 „
	7·6 „	3·5 „	5·5 „
Mean ...	5·3 per cent.	3·7 per cent.	4·3 per cent.
	7·7 „	5·8 „	5·4 „

The Thomson's galvanometer carefully insulated was fitted with four shunts of $\frac{1}{9}$th, $\frac{1}{99}$th, $\frac{1}{999}$th, $\frac{1}{9999}$th of that of the bobbins of the galvanometer. The resistance boxes forming the shunts were also insulated with great care. The experimental battery consisted of 330 small Callaud elements to which there could be further joined 60 accumulators, giving a total electromotive force of 460—470 volts. These elements had during all the course of the measurements a very constant electromotive force scarcely varying from 1·06 to 1·02 volts

in the lapse of three months. They were also arranged in groups of 10 so that the difference of potential employed in the measurements could be varied at will.

It is known that temperature exerts a great influence on the insulating power of a dielectric. It was, therefore, necessary to effect the measurements as far as possible at a constant temperature, the more so as they require a long time in consequence of the necessity of completely discharging the cable before each observation.

Herr Heim has taken every precaution to satisfy these conditions, either by plunging the cables into water or by surrounding them with a coating which is a poor conductor of heat.

In order to diminish the residue in the cables, the measurements have been effected in general with a time of charging of only one or two minutes. But the duration of the electrification has a very sensible influence upon the insulation; the insulation after a prolonged electrification is the element which it is important to know in cables with a continuous current. Thus Herr Heim in all his series of observations effected each measurement with an electrification lasting 15 minutes.

It must be noted that in every measurement a beginning has been made with low potentials which have then been gradually increased.

The measurements of Herr Heim have given a conclusive result, which appears clearly from the table No. I.

TABLE II.

Nature of Cable.	Difference of potential in volts.	Insulation in megohms. Time of electrification in minutes. 1	2	3	5	10	15
Gutta-percha	53	7,500	8,495	9,020	9,536	10,100	10,540
„ „	213	7,200	8,250	8,740	9,370	9,950	10,480
„ „	470	7,050	7,960	8,420	9,015	9,570	10,000
Leaded, No. 1	21	2,290	2.870	3,530	4,495	6,480	8,215
„ „	213	2,185	2,730	3,250	4,280	6,290	7,955
„ „	470	2,180	2,720	3,210	4,190	6,090	7,670
Leaded, No. 2	53	14,750	20,200	24,456	29,800	40,500	47,700
„ „	213	13,500	19,200 ?	23,200	29,200	38,100	43,950

That is, that the insulation of the cables diminishes with the potential of the current by which they are traversed.

We do not give the values deduced from each measurement for the insulation of the core of the copper insulated with gutta-percha and of the two leaded cables; we shall limit ourselves to sum up the values in percentages of the decrease of insulation for the different increases of potential.

TABLE III.

Cable.	Ratio of potential in volts.	Decrease of insulation per cent. Duration of electrification in minutes. 1	2	3	5	10	15
Gutta-percha	53 : 470	6·0	6·3	6·6	5·4	5·3	5·1
„ „	53 : 213	4·0	2·9	3·1	1·7	1·5	0·6
Leaded No. 1	21 : 470	4·8	5·2	9·1	6·8	6·0	6·6
„ „	21 : 213	4·6	4·9	7·9	4·8	2·9	3·2
Leaded No. 2	53 : 213	8·5	5·0	5·1	2·0	5·9	7·9

Of the values given in Table I., we see that the decrease of insulation for the greatest variation of potential (50 volts to 460 volts) is about 7 per cent. for the core insulated with gutta-percha, 6·5 per cent. for cable No. 1, and 3 to 4 per cent. for cable No. 2.

The results obtained by Herr Heim on the influence of the duration of electrification upon the insulation of the cables are summed up in Tables II. and III. The latter gives in percentages the decrease of insulation along with the increase of the potential.

These values show that the variations of insulation with potential are the same for short as for long durations. This conclusion shows that in this kind of measurement it is useless to employ considerable durations of charge.

TABLE IV.

Observer.	Difference of potential in volts.	Duration in minutes. 1	2	3	5	10	15
Frœlich ...	?	1·00	1·11	1·15	1·24	1·33	1·37
Heim	53	1·00	1·13	1·20	1·37	1·35	1·40
„	213	1·00	1·14	1·21	1·30	1·38	1·46
„	470	1·00	1·13	1·19	1·28	1·36	1·42

If we take as a unit the insulation of gutta-percha after a minute of electrification, the values of the insulation after 1, 3, 5, 10, 15 minutes are given in Table IV.; the first line refers to the values given by Herr Frœlich in his treatise on electricity. Lastly, the values corresponding to the two leaded cables studied by Herr Heim are summed up in Table V.

TABLE V.

Leaded cables.	Potential in volts.	Duration in minutes. 1	2	3	5	10	15
No. 1	21	1·00	1·25	1·54	1·96	2·83	3·59
„	213	1·00	1·25	1·40	1·96	2·88	3·64
„	470	1·00	1·25	1·47	1·92	2·80	3·52
No. 2	51	1·00	1·37	1·66	2·02	2·74	3·24
„	213	1·00	1·42	1·72	2·16	2·82	3·26

All these results have been obtained at a temperature approximately constant. It remains for us to study the influence of temperature upon insulation, an influence which is considerable, but which is accurately known only for gutta-percha. Its determination will be interesting for leaded cables insulated with a compound of resins and paraffins.

TABLE VI.

Time.	Potential in volts. 2	20	102	400	Temperature.
h. m.					
3 15	...	6·16	...	...	
3 36	...	...	3·72	...	
4 23	...	6·53	...	...	17·2°
4 47	...	...	...	2·72	
5 46	...	6·68	...	...	
3 52	17·0	...	...	...	
4 28	...	8·00	...	...	17·2°
5 34	17·2	...	...	...	
5 50	...	...	4·66	...	
10 42	...	0·75	...	...	
11 35	...	...	0·55	...	
12 35	...	1·01	...	...	
1 3	...	...	...	0·50	Heat engine
4 10	...	0·82	...	...	
4 41	...	...	0·67	...	
5 12	...	1·02	...	...	

We may also mention the measurements which Herr Heim has made on the insulation of the field magnets of a Schuckert machine in derivation. These measurements have been made both in cold and in heat after having passed a current of 2 ampères per square millimetre into the magnets for six hours. The results in megohms are summarised in Table VI., which shows a decided decrease of insulation with the increase of potential, and, besides, how much the insulation measured in heat differs from that which is measured upon the machine in the cold.

These results prove that the measurement of the insulation of a machine should be made when the latter is hot, and with a difference of potential the same as that at which the machine works.

The values in megohms of the insulation with refer-

ence to the earth of two circuits placed along the sides of a hall are shown in Table VII. The circuit, A, was composed of a copper cable of 19 strands of 1·2 millimetre surrounded first with an incombustible ribbon, then with a ribbon saturated with gutta-percha, and then with cotton steeped in tar. This cable was 150 metres in length; it was fixed upon small shelves by means of ordinary hooks. The circuit, B, was common bell wire of 0·9 mm. insulated with cotton soaked in paraffin. It was fixed to the plastered walls by means of common hooks.

TABLE VII.

Potential in volts.	Insulation in megohms.	
	Circuit A.	Circuit B.
2	0·63	0·124
20	0·58	0·091
2	0·61	0·117
120	0·50	0·085
3	0·75	0·111
20	0·57	0·100
2	0·60	0·119

The results of Table VII. show that in a lighting installation where the difference of potential is 100 volts a battery of few elements may serve to verify the insulation of the cables.

Herr Heim concludes his work by submitting the measurements of Fordenreuther to a very thorough criticism. He shows in particular that Fordenreuther has not taken temperature into consideration, and that certain series of measurements which lasted longer than one day are discussed without taking this factor into account.

PROMISING ELECTRICAL PROGRESS.

THE Shakesperian adage about the tide in the affairs of men which taken at the flood leads on to fortune was, perhaps, never more strikingly illustrated than in the case of some of the electrical enterprises of the present day. Amongst the foremost of these is entitled to be placed the firm referred to in the notice boards conspicuously placed on many buildings in the metropolis, stating that the electric lighting is by Rashleigh Phipps and Dawson. The concern was commenced only three years since in a very modest way in premises in Gray's Inn Road, which had the appearance of having been originally put up as stables, but with alteration, made to do duty as workshops. This happened to be just the time when a large demand was springing up for electric lighting, and by laying themselves out to meet the prevailing tastes, the new firm soon found their productions in such request, that they were compelled to take large works and show rooms in a much better, if more highly rented, locality. At No. 53, Berners Street, they have now what we believe is the most extensive manufactory in this country devoted exclusively to the production of fittings for the electric light, though undoubtedly there are larger establishments in which the making of these goods has become an important branch. In Messrs. Rashleigh Phipps and Dawson's show rooms at Berners Street a very fine display is made of fittings to suit every requirement, every one of which is connected up, so that the effect when lighted can be shown in a moment. The originality of many of the designs may perhaps be partly explained by the fact that they have been thought out from the standpoint of the electrician, and are thus free from the mannerisms sometimes observable in the work of men who have been a lifetime engaged in designing fittings for gas. By means of a staff of artists and designers, special patterns, when required, are produced to harmonise with any particular style of decoration or furniture.

The firm has just issued a catalogue of electric light fittings, handsomely printed in colours, giving a good idea of the style and appearance of a considerable number of these articles. It is, however, pointed out in the preface that it has not been thought advisable to include in the book some of the best and most elaborate patterns. The publication, indeed, seems intended more as an invitation to those interested to visit the show rooms, where illustrations will be found in sufficient variety of style to meet every taste and requirement. A matter to which considerable attention is given is that of lamp shades, the prevailing material employed for these being silk. A very pretty and striking lamp shade is afforded by mother-o'-pearl shells, the effect of which may be seen in a newly-opened bookseller's shop at the corner of Berwick Street and Oxford Street, where the lamps have been fitted with such shades.

The manufacture of fittings has developed so rapidly, that the present workshops in Berners Street are already found to be too small, and additional room is being made, by excavating below the premises, for sixty additional lathes and an extra engine.

The making of fittings is, however, only a subordinate part of the business of the firm, which embraces the supply of every requisite for the electric light, and the carrying out of all the needful work involved in its installation. As a matter of history, it may be mentioned that six years ago, or more, Mr. Rashleigh Phipps fitted up what was almost the first domestic installation in London using a gas engine and accumulators. This, we understand, has been running almost without a day's cessation up to the present moment. The first year or two we were supplied with figures, which we published at the time, showing the cost of maintenance of this interesting experimental installation. Since that time some of the most important work in the metropolis has been put into the hands of this firm, such, for instance, as the lighting of the Garrick Theatre with about 1,000 lights, said to be the most artistically-lighted theatre in London; the new Tivoli Theatre and Restaurant, which are also beautifully lighted, the fittings for which were designed and manufactured within two weeks from the date of order; and, more recently, the Standard Music Hall, where between 300 and 400 lights have been put in. Amongst large installations of a more private though not less important nature which have been carried out by the firm may be mentioned the new mansion of Mr. Robert Harrison, Shiplake Court (300 lights with duplicate plant); Mr. Warren De la Rue's house, Newmarket (200 lights with steam plant and accumulators); and Messrs. Marshall and Snelgrove's, Oxford Street (complete plant). The firm have compiled and published a list of recent installations, consisting of no less than 74 private houses and 20 houses in which complete plant with accumulators has been installed.

The firm pride themselves on their promptness. The Architectural Association gave a *conversazione* on the evening of the 3rd inst., at the Westminster Town Hall, on which occasion the whole of the rooms were brilliantly lighted, the lamps and shades assuming many different forms and colours, some of them exceedingly artistic. The lighting was carried out by Messrs. Rashleigh Phipps and Dawson, the current being supplied specially by the Westminster Electric Supply Corporation. Owing to this arrangement, even when the rooms were most crowded, the air was tolerably cool. The whole of the work connected with this temporary installation was completed in three days.

Enough has been said to show that whatever others may do, the firm to whom reference is here made are determined to take their tide of prosperity at the flood, and we hope it will lead them safely on to fortune.

A most diversified catalogue of electric light fittings has just been issued by Messrs. B. Verity and Sons. It was, we understand, got up in Paris, and it can be seen at a glance that no expense has been spared in its preparation. It consists of 48 large sheets, each consisting of a number of patterns, including pendants, brackets, electroliers, standards, and every other form in which such articles are made. Nearly every pattern illus-

trated is kept on view in the showrooms of the firm at King Street, Covent Garden, and Regent Street, and the same pattern can be supplied in polished brass, bronze, nickel silvered, or electro silvered. At the show rooms there are also replicas of many of the finest examples of French and Italian girandoles, &c., in mercury gilt, any of which can be fitted for electric light. The price list contains a notice that Messrs. B. Verity and Sons have in preparation a catalogue of electrical sundries, in which particulars will be given of the "Verity patent quick make and quick break" switch, and the "Verity patent safety cut-out," by the use of which it is impossible to fix a large fuse into a block intended for a smaller size. The firm is devoting a large amount of attention to the designing and making of good switches, switchboards, resistance frames, battery cut-outs, wall attachments, and such like accessories. High-class switch covers in Louis XIV. and other French styles, finished in gold, silver, or bronze, are specially treated, to suit the ornamentation of rooms. We are not surprised to learn that the vast expansion of Messrs. Verity's business through the prominent position they have taken in the electric lighting industry has necessitated their establishing a factory at Birmingham.

The Electric Light in Brussels.—In a few days from now the authorities of Brussels will open a competition for a model of the Venetian masts (to which we referred last week) intended to support the electric lighting apparatus in the Grand Place.

IMPROVEMENTS IN TELEPHONE EXCHANGE SWITCHBOARDS.

THE switchboard in every telephone exchange forms perhaps the most important part of any of the requirements. For all large exchanges of over 400 subscribers the well-known multiple boards are principally used in this as well as in other countries. They have from time to time been subject to much attention and many improvements, while the switchboards for all small exchanges have been comparatively neglected, and many of the oldest and worst type are still at work. We therefore have much pleasure in giving particulars which have been furnished us relating to the switchboard shown by figs. 1 and 2.

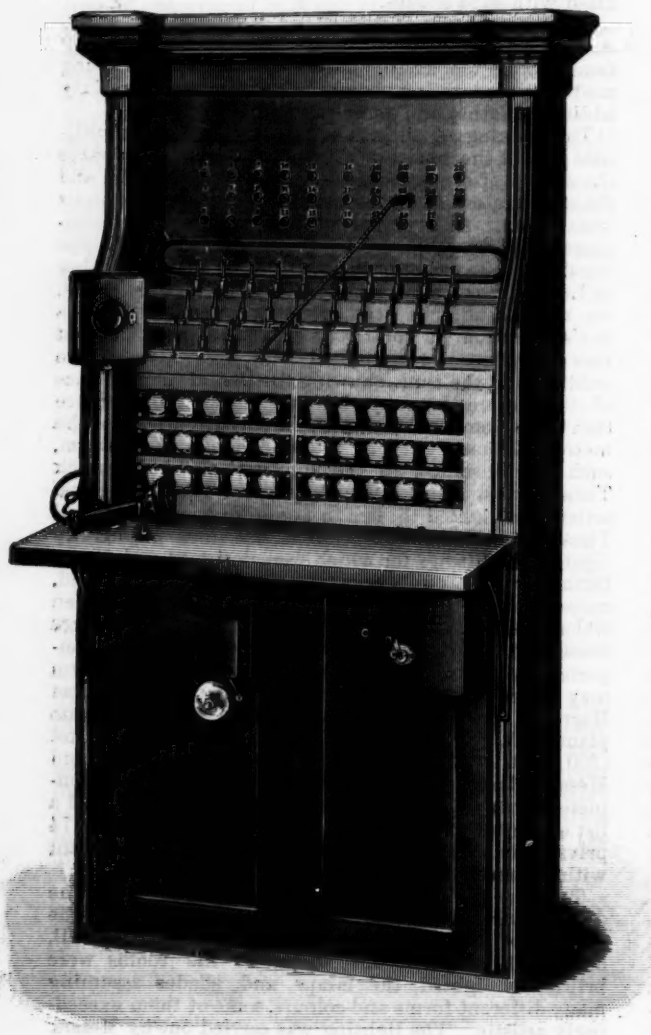


FIG. 1.

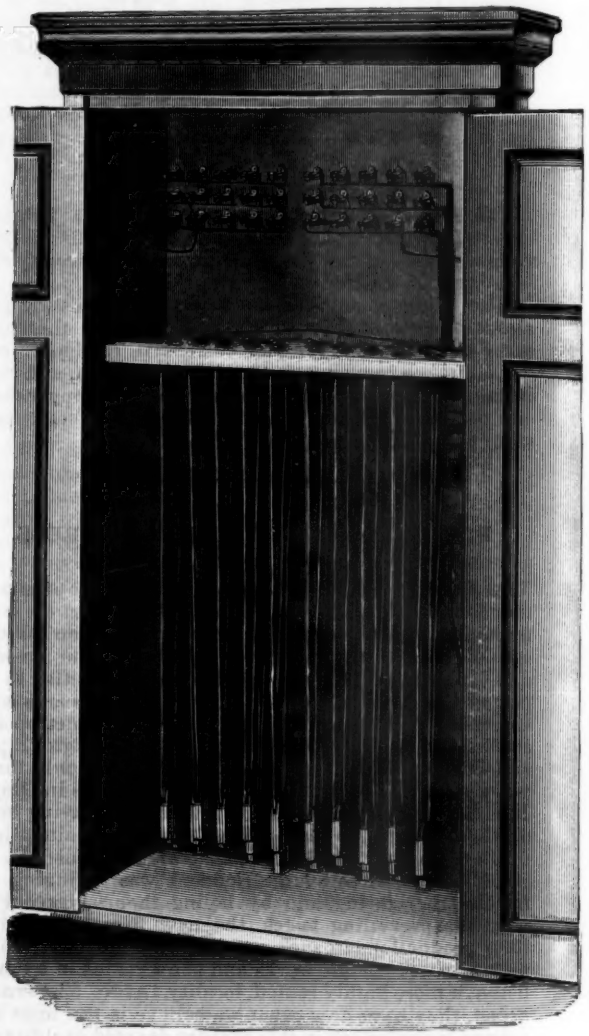


FIG. 2.

These switchboards are known as single-cord boards They were designed by Mr. D. Sinclair (late engineer for the Glasgow district and now the London manager of the National Telephone Company), and were manufactured by the Telegraph Manufacturing Company, Helsby.

The particular board shown by figs. 1 and 2 (fig. 1 being a front, and fig. 2 a back view showing the cord pulley weights), is fitted for 30 lines, this being a standard pattern for any number of lines from 25 up to 150.

The electrical connections, as shown by fig. 3, are of the very simplest nature, and are so arranged as to give the best electrical and mechanical condition when any two lines are joined together with the least possible

amount of work to the operator. L^1, L^2, L^3, represent three subscriber's lines led into the exchange. J^1, J^2, J^3, are the jacks, I^1, I^2, I^3, the indicators C^1, C^2, C^3, the wire cords, P^1, P^2, P^3, the terminal plugs and T the operator's table. A connecting wire cord with a single plug is permanently attached to each line led into the switchboard in the exchange, and when one subscriber, as, for example, Number 1, is to be connected to another, *e.g.*, Number 2, the operator, inserts the plug, P^1, constituting the terminal of Number 1 subscriber's line into the jack, J^2, in the line of subscriber Number 2, thereby also cutting the second subscriber's indicator, I^2, and earth out of the line to which connection has been made, whilst leaving in circuit the indicator, I^1, of the line whose terminal plug, P^1, has been used.

It will be seen that there is the usual line jack and indicator for each line, but instead of the line in the ordinary way going direct to earth after passing through the indicator, it goes, as shown, to a cord, and finds earth at the plug, the latter being placed normally in contact with earth terminals at *t* on the table, T. In this way, there is a a cord and plug for each line on the board, and as one end of the cord is permanently attached to the line, it only requires (as has been explained) for the plug of any line to be inserted into the line jack of any other line to make connection between the two, while if a loose cord, with a plug on each end of it is used, as in ordinary small switchboards, it is plain that much more work is necessary in making a connection. Lifting the plug of any line disconnects it from the earth, leaving the indicator in circuit, so that when the plug is inserted into the jack of any other line, this indicator acts as a "ring off" indicator, and the act of inserting it cuts off the indicator cord and plug of the line inserted, so that only *one* indicator is in circuit when any two lines are joined together.

In the old boards both indicators were left in circuit, or they were both cut off, left idle, and a special ring-off indicator provided in the cord circuit; but this was hardly ever carried out in practice on small boards. On the old boards, indicators were wound to a resistance of about 80 ohms, so that with two in circuit the resistance to stable measurement was 160 ohms, which, with the amount of self-induction and retardation, produce very bad effects upon the communication. The indicators adopted in these boards are somewhat of the old type, but joined up in parallel, so that the ordinary resistance is about 20 ohms. These are found to act perfectly well for all telephone lines of the ordinary length.

The operating of the board is as follows: say No. 5 wishes any one he rings, his indicator drops, and the operator inserts her general operating plug into the line jack, and receives instructions. If No. 10 is asked for, the operator removes general plug into that No. and rings. When No. 10 replies, the plug of No. 10 line is inserted into jack of No. 5 line, and so the connection is complete. Operator generally waits with her plug tapped on until the two parties are heard in communication. When the conversation is finished, either one or both ring off (it ought to be the party who first applied, but it is difficult to get subscribers to work to any rule), and the operator disconnects the plug, which automatically finds its way back to rest and earth by the ordinary pulley and weight arrangement.

This operation, as compared with the old system, where there were no special keys and cords used, saves about 50 per cent. of the operator's work, and as compared with the system of providing special keys and cords, about 30 per cent. of the operator's work. It is likewise a great advantage on a busy board to have only one half the number of cords to deal with, as it prevents any confusion to a great extent.

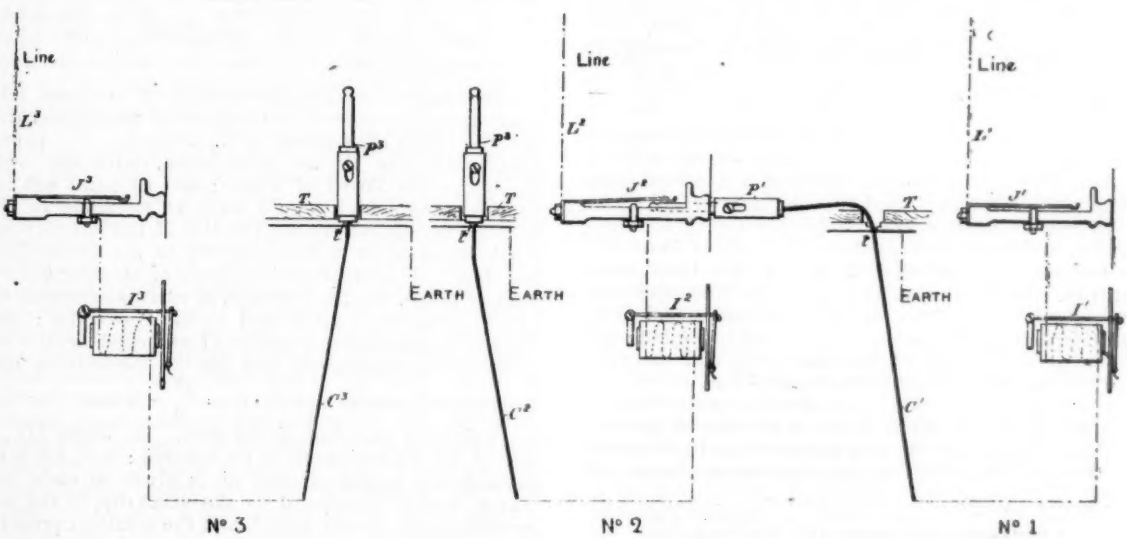


FIG. 3.

This system was first introduced about three years ago, and it is now extensively used in this country, and continues to grow in favour. Several switchboards of this kind have been supplied for use abroad, and have given much satisfaction.

SOME NOTES ON OVERHEAD LINES.

By STUART A. RUSSELL.

THE purpose with which these notes have been written is not to discuss the general question of overhead lines, but rather to direct particular attention to that part of the subject which deals with the mechanical strains which they have to withstand; and to compare the present practice as regards overhead electric light and telegraph lines with the regulations for the construction of the former which have been issued by the Board of Trade.

Having recently had occasion to work out the particulars of an overhead line, I was somewhat

astonished to find that the Board of Trade regulations required it to be so much stronger and heavier than has been previously considered necessary; and it appeared to me to be worth while to draw attention to the comparison mentioned above, in the hope that others, who are interested in this matter, would be able, by quoting their experience, to bring together a mass of practical information which would help in the drawing up of a specification which, whilst providing for a perfectly safe line, would not entail needless expense on its construction.

The chief reason of the increased weight of the line is to be found in Section 29 of the regulations*, which specifies for a wind pressure of 50 lbs. per square foot, and a factor of safety of six for the suspended wire, and of twelve for all other parts of the line; whereas previous practice has assigned a much smaller value to the wind pressure, and has generally used a factor of safety of four. Here I may mention with regard to wind pressure, that there seems to be considerable doubt as to what is the actual effective pressure on a suspended wire; no reliable experiments on the subject have been made and published so far as I can find; and values varying from 0·5 to 0·75 are given by different writers to the coefficient, by which the pressure exerted on a plane surface perpendicular to the direction of the wind has to be multiplied to get the corresponding pressure on a suspended wire. The value I have given to this coefficient is 0·6, thus making the pressure on the wire per foot run $P_1 = \frac{0{\cdot}6 \times P \times d}{12}$ $= {\cdot}05\ P\ d$, where P is the pressure per square foot on a plane surface, and d is the diameter of the wire in inches. For comparison, the particulars of several lines are given in Tables I. and II.; the former being for lines erected in accordance with Board of Trade regulations, and the latter for lines such as would be erected in accordance with what I believe has been usual practice. In both cases the cables are insulated with vulcanised India-rubber to the thickness specified by the Board of Trade, and then taped and braided; the suspension wires are of stranded steel, and the span and dip are respectively 200 feet and 5 feet.

These tables show how considerable is the increase required by the Board of Trade in the size of the suspension wires, and if we now suppose such lines erected on the housetops, and calculate out the strains on the supports, we shall find that it will be necessary to provide saddles long enough to take a bearing on two or more roof principals, and that the difficulty of finding good anchorage for the stay wires will be very considerable; indeed, in some cases, it might even be necessary to rebuild a great part of the top of the house before it would be strong enough to bear the strain. It must here be borne in mind that the factor of safety for the supports is 12, and if this is to be applied to the roof of the house as part of the support, I am afraid we shall not be able to find many that will satisfy the specified conditions. Tables I. *a* and II. *a* give the strains on the supports and size of stay wires for double conductor lines of 7/20 and 19/15 cables; the former for a wind pressure of 50 lbs. per square foot and a factor of safety of 12; and the latter for a wind pressure of 20 lbs. per square foot, and a factor of safety of 6.

Size of conductor.	Side strain at point of support.	Strain in stay wire at angle 45°.	Size of stay wire.	Vertical component of strain in stay wire.	Weight of line.	Total pressure on roof.	
7/20	778	1,104	19/14	778	150	1,150	Table
19/15	1,130	1,598	19/13	1,130	363	1,750	I. *a*.
17/20	235	332	7/18	235	67	450	Table
9/15	355	502	7/16	355	227	750	II. *a*.

Coming now to the consideration of overhead telegraph lines, I propose to compare some data concerning the Post Office lines given by Mr. Preece, in two papers read before the British Association, with the regulations of the Board of Trade; and to point out the modifications which would have to be made in Mr. Preece's figures, before the practice of the one Government Department would conform to the demands of the other. The paper read at the 1887 meeting gives a table of spans, dips, and strains, at various temperatures for the three wires most used by the Post Office; and also states that a factor of safety of 4 is allowed for all wires at minimum temperature, and that the calculations have been made from the formula $d = \frac{a^2\ w}{8\ t}$ where "w" is the weight of one foot of the wire. In Table III., a part of Mr. Preece's table is reproduced; and, for comparison, the length of span a^1 is given in each case which would correspond to the same dip, if the permissible strain in the wire t^1, and the resultant pressure

* See ELECTRICAL REVIEW, 17th October, p. 461.

TABLE I.—Wind pressure, 50 lbs. per square foot. Factor of safety 6.

Insulated cable.				Suspension wire.					
Copper strand.	Outside diameter.	Weight per foot run.	Wind pressure per foot run.	Steel strand.	Diameter.	Weight per foot run.	Wind pressure per foot run.	Safe working tension.	Strain at insulator.
7/20	·418	·108	1·045	19/15	·360	·268	·900	1,970	1,980
7/18	·454	·141	1·135	19/14	·400	·331	1·00	2,430	2,190
7/16	·502	·195	1·255	19/14	·400	·331	1·00	2,430	2,320
19/18	·550	·257	1·375	19/14	·400	·331	1·00	2,430	2,440
19/16	·630	·385	1·575	19/13	·460	·437	1·15	3,200	2,850
19/15	·670	·470	1·675	19/13	·460	·437	1·15	3,200	2,970

TABLE II.—Wind pressure, 20 lbs. per square foot. Factor of safety 4.

Insulated cable.				Suspension wire.					
Copper strand.	Outside diameter.	Weight per foot run.	Wind pressure per foot run.	Steel strand.	Diameter.	Weight per foot run.	Wind pressure per foot run.	Safe working tension.	Strain at insulator.
7/20	·418	·108	·418	7/17	·168	·059	·168	650	610
7/18	·454	·141	·454	7/16	·192	·077	·192	850	682
7/16	·502	·195	·502	7/16	·192	·077	·192	850	746
19/18	·550	·257	·550	7/16	·192	·077	·192	850	814
19/16	·630	·385	·630	7/15	·216	·098	·216	1,080	974
19/15	·670	·470	·670	7/15	·216	·098	·216	1,080	1,050

per foot run w^1 are calculated to Board of Trade specification; *i.e.*, if $w^1 = \sqrt{w^2 + (2{\cdot}5\ d)^2}$ and $t^1 = \frac{2\ t}{3}$

TABLE III.

	d.	w.	t.	a.	w^1.	t^1.	a^1.
No. 7¼ iron wire..	3·18	·076	270	300	·432	180	102
„ „ „ ..	1·14	·076	270	180	·432	180	62
No. 12½ hard drawn copper	2·66	·028	120	300	246	80	84
	0·97	·028	120	180	246	80	50
No. 14 hard drawn copper	2·66	·019	80	300	·201	54	76
	0·97	·019	80	180	·201	54	46

From this it will be seen that the Board of Trade would require from three to four times as many poles to be used according to the size of wire; a change which would add considerably to the cost; and would, by increasing the number of insulators, seriously diminish the insulation resistance of the line. Of course the number of poles need not be increased to such an extent if a greater dip is allowed; but a limiting maximum dip is soon reached in lines carrying several wires, owing to the increased danger of contacts when the wires are swayed by the wind; and even a dip of 10 feet would only allow of a span of 180 feet for the iron wire, and of 142 feet for the No. 14 copper wire.

Mr. Preece's other paper, which was read at the 1885 meeting, deals with the strength of wooden poles, and gives some very valuable experimental results obtained at the Gloucester Road factory, concluding with two tables giving the safe diameters of poles for 60-yard spans of 17 and 20 wire lines, calculated for a wind pressure of 18·75 lbs. per square foot with a coefficient of 0·6 and a factor of safety of four. Comparing these figures (which, it may be noted, Mr. Preece says are well confirmed by the results of practice) with those specified by the Board of Trade, it will be seen that the wind pressure in the latter case is 2⅔rd times that in the former; and therefore for lines which are otherwise similar, the moment of pressure on the pole will be increased in the same proportion. Since, however, the Board of Trade factor of safety is 12, or three times that used by Mr. Preece, the actual strength of the poles must be as 8 to 1, which means, if they are of circular section, that their diameters must be as 2 to 1. If the length of span is reduced as in Table III., there will be from 3 to 4 times as many poles required, each of which will need to be from 2⅔rd to 2 times as strong as those given by Mr. Preece for his longer spans.

A consideration of the results given above naturally leads to the question, are all the Post Office lines and all the electric lines absolutely unsafe, or are the present regulations of the Board of Trade unnecessarily stringent? The answering of the first part of this question, so far as it relates to the telegraph lines, may well be left to the engineers of the Post Office, who have the experience of many years to guide them; and, with regard to the electric light lines, I believe I am correct in saying that, in London at any rate, no accident has happened through mechanical weakness, although some of them were exposed to the storm of December 26th, 1886, which played such havoc with many of the overhead lines throughout the country. From these facts I can only come to the conclusion that the Board of Trade regulations are needlessly stringent, and that if they are enforced they will be the cause of a considerable useless expenditure of money; so much so, indeed, that the regulations might almost as well forbid the use of overhead lines at all, as their cost will be so nearly equal to that of putting the cables underground. As an advocate of underground work whenever possible, I am generally glad to welcome everything which will increase the use of subterranean cables; but, at the same time, I cannot but regret any unnecessary increase in the cost of overhead wires, seeing that they may do such excellent service in opening up new districts, which, from the small number or scattered positions of their lights, are practically shut out from all chance of an electric service by underground cables; and for this reason I would be glad to see an alteration in the Board of Trade regulations, which, while providing for a perfectly safe line, would yet allow of that line being erected at a moderate cost.

THE SARDINIA STREET STATION.

THE largest station of the Metropolitan Electric Supply Company is situated in Sardinia Street, at the side of Lincoln's Inn Fields, W.C., and is the first to be carried out in so far as the internal arrangements are concerned, by the English Westinghouse Electric Company on its well-known system. The erection of the station was commenced in the early part of 1889, and the building was completed just over a year ago. At the time, however, only half of the generating plant was installed, but now the whole of the machinery is in position and the station may be considered as practically complete. The station occupies a large area of ground, and has recently been increased in size by the acquisition of an adjoining building which was formerly used by a basket maker, and which is now utilised partly as a storeroom and partly for housing a portion of the staff.

There are two entrances in Sardinia Street, one giving access through the offices to the south side of the station, and the other being a cart entrance for coal waggons to pass into a large shed. Underneath this shed is a large vault capable of containing 500 tons of coal, which is shot down through trap-doors. On the eastern side of the shed is situated the fuse room, a large oil room and a store room for engine and dynamo bearings, bolts, and other replaceable parts of the machines. The station itself, which is a two storeyed building, is on the western side of the shed, and the boiler house forms a separate building on the north of the station. This house contains a battery of twelve Babcock and Wilcox boilers, five being erected on one and seven on the other side. They are each of about 210 H.P., are all connected together by a ring of steam piping, and work at a pressure of 150 lbs. There are three Worthington pumps which supply water to three feed-water heaters of the Babcock and Wilcox type. A fan is in course of erection so as to allow of the use of forced draught in order to get up steam quickly, as for instance on a fog suddenly occurring. In the middle, and throughout the length of the boiler house, is laid a narrow gauge tramway for coal trolleys, the rails terminating inside the large vault already mentioned. Thus the coal can easily be conveyed to the boiler furnaces.

The engine room occupies the ground floor of the station, and is very spacious and lofty. A wide central passage has been arranged longitudinally, and on either side are erected five Westinghouse compound engines. Of these 10 machines, five are of 250 H.P. each running at 280 revolutions, whilst the remaining five are of 300 H.P. each and make 250 revolutions a minute. These engines are the largest of the Westinghouse type yet introduced into this country. In addition to these, there are installed in one corner of the engine house three smaller engines of 65 H.P. each, the speed being 300 revolutions. These three engines actuate the exciters. Steam is supplied from a main steam pipe, asbestos jointed, arranged in the form of a ring, suitable branch pipes being conveniently led off. The foundations for all the engines are very well and solidly constructed, being composed of concrete and brickwork. From the large flywheels the belts pass up overhead at an angle of about 30° through belt holes into the dynamo room on the upper floor. The latter is an equally spacious and lofty room containing 10 Westinghouse alternators running at 1,050 revolutions, and having an output of 125 kilowatts each, the pressure being 1,000 volts. The three exciting dynamos, which are also of the Westinghouse type, run at 900

revolutions with an output of 300 ampères at 100 volts, and any one is sufficient to excite the field magnets of six alternators.

The switchboard is a very complete and elaborate arrangement. It is mounted upon panels of polished block slate along one side of the room, with a space of about 30 inches left behind for connections. All the wires to switches, cut-outs, resistance frames, &c., here converge, the instruments for each machine being placed on polished mahogany boards one above the other, with the switches within easy reach, giving ready manipulation and inspection. The switchboard can properly be divided into three distinct parts; first, the exciter switchboard; second, the alternating current dynamo switchboard; and third, the distributing circuit switchboard. Each exciter is operated from the first-mentioned portion of the board, and is entirely controlled by the apparatus there. The latter consists of three rheostats which are in the field circuits of each exciter, the three main exciter switches and the multiple arcing switches for throwing the three exciters together. This is usually done only on changing over from one machine to the other. The second portion, or alternating current dynamo switchboard, consists of two single pole switches for each dynamo, one double pole exciter switch for each dynamo, one ammeter and one field rheostat. By throwing in the main dynamo switch, the operator simply connects the dynamo to two trunk line wires running on the back of the board from end to end. There is a corresponding set of wires for each of the alternating current machines, and it is impossible by any manipulation of the switches on the dynamo switchboard to throw two dynamos in parallel or to short-circuit one dynamo through another, should one be standing still, and the other running at its full E.M.F.

The third portion of the board consists of a dynamo changing switch, a complete set of plugs for cross connecting any dynamo to this particular switch, an ammeter, compensator, and a voltmeter for each of 20 circuits.

There is also in each of the distributing circuits a transformer which is used simply to furnish a secondary current to the circuit voltmeters. The latter reads at 100 volts when the high tension current is at 1,000, the ratio of conversion being ten to one.

Each of these main distributing circuits has also a compensator in the voltmeter circuit. This compensator is set to allow for a certain percentage of drop, whatever it may be, on the line, and by its action on the voltmeter circuit, the reading of the instrument (which is zero reading), is affected in proportion as the load comes on the circuit. Consequently it is only necessary to alter the rheostat in either the main exciter circuit or field circuit of the individual machine, in order to bring the needles back to the zero point, thus allowing for the drop in E.M.F. on the distribution circuit.

From the switchboard proper in the station, the twenty circuits from the corresponding number of distribution circuit switches are led to the fuse house across the yard. The twenty circuits are again subdivided as necessity demands. In some cases one of the twenty main distribution circuits will be divided again into six, or the entire current from one of these main circuits may be taken out by one cable. The object has been to subdivide the lighting circuits as much as possible, but up to the present no necessity for this subdivision has arisen, other than that due to shutting off the current in order to connect a new subscriber. Each of the fuse boards in this house consists of six single pole switches, and six fuses of the Wurts patent. These while quite open, absolutely prevent any chance of an arc being produced between the binding posts, if by any means the external line should become short circuited. Each circuit is labelled with the name of the street in which the cable is laid, and any circuit can be cut out as desired. These cables are then carried into a cellar underground where the street mains are brought in. The fuse room is fitted with an elaborate set of testing apparatus.

The cables employed by the company are of the well known Silvertown type, the largest size used being 37/16, and the smallest, 7/16. The conduits consist of iron pipes, cast vertically, and ranging from 3 inches to 5 inches in diameter. They are partly laid under the footpath, near the kerbstone, and partly under the carriage way. In some cases, owing to the existence of high cellar arches, &c., the conduits have had to be laid so that their upper surfaces are almost in contact with the flagstones. Junction boxes have been provided at suitable intervals, and the house connections are made by means of loops, no T joints being used except in Lincoln's Inn Fields, where mains were first laid.

On each consumer's premises are installed a Shallenberger meter, which type, it will be remembered, has come into extensive use in the United States; a Westinghouse converter, and a main switch. The interior wiring has to be effected by consumers under the regulations of the company, and those laid down by the Board of Trade.

The mains are laid in rings so as to minimise the danger of extinguishing a number of lights in case of a breakdown. All the stations of the Metropolitan Company are connected together by trunk mains, so that one station may take over the load of the other or a portion thereof if necessary.

Customers are usually charged for light by meter at the rate of 7½ per Board of Trade unit, which is equivalent to ¼d. per eight candle-power lamp per hour; but a fixed rate per lamp per annum may be arranged. For instance, the charge for an eight C.P. lamp, burning on an average three hours daily, is £1 per annum. The company's other charges which are for annual rent of transformer, main switch and meter, are as follows: transformer, £1 per annum for every 50 eight C.P. lamp, or a less number; main switch, 7s. 6d. per annum, and meter, £1 per annum. The total cost is thus brought up to 8d. per Board of Trade unit. The station buildings were designed by Mr. Robert Walker, A.R.I.B.A., and Mr. Frank Bailey, A.M.I.C.E., is the engineer to the company.

EFFICIENCY OF THE EDISON-HOPKINSON DYNAMO AND WILLANS CENTRAL VALVE ENGINE.

VARIOUS tests have been published from time to time of the efficiency of Messrs. Willans and Robinson's central valve engine, and the various types of dynamos with which they are combined. At a recent test made at Thames Ditton with a large Edison-Hopkinson dynamo, constructed by Messrs. Mather and Platt, of the Salford Ironworks, Manchester, a result has been obtained giving an efficiency superior to anything previously attained.

The results show an efficiency of engine and dynamo combined, *i.e.*, the ratio of the electrical power available for useful work outside the dynamo to the indicated power of the engine of 86·7 per cent.

The following are the particulars of the engine and dynamo:—Compound double-crank engine with low pressure cylinders, 14 inches diameter, stroke 6 feet, to work with 120 lbs. steam pressure, driving direct an Edison-Hopkinson dynamo, constructed for an output of 110 volts, 475 ampères, at 430 revolutions per minute. The dynamo has a bar armature (patent No. 4,884, 1886, John Platt, John Hopkinson, and Edward Hopkinson), and is shunt wound only, and is fitted with a commutator of hard drawn copper, with mica insulation, with four brushes on each rocking arm.

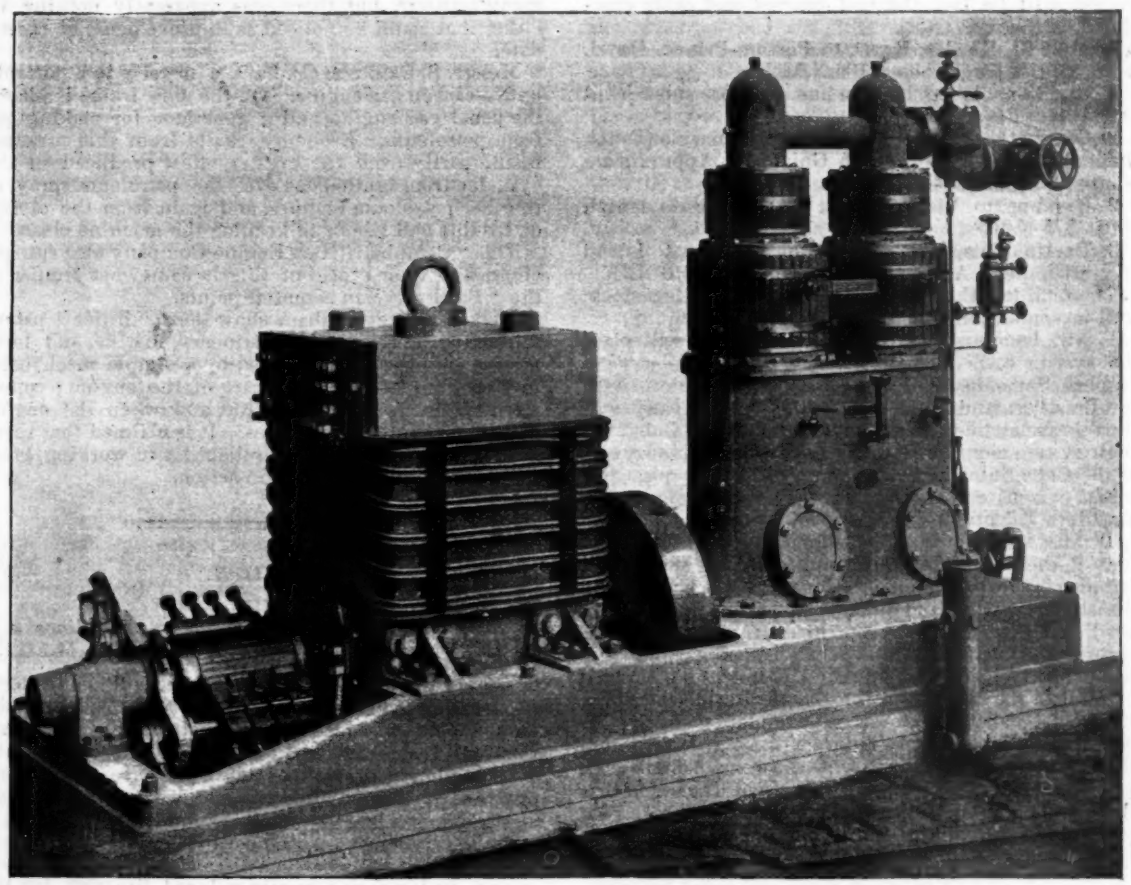
Resistance of magnets	...	16 ohms.
Resistance of armature	...	0·0055 „
I.H.P.	...	83·3
E.H.P.	...	72·2
Hence efficiency		86·7 per cent.
Consumption of water per I.H.P hour	...	21·6 lbs.
„ „ „ E.H.P. hour	...	25 lbs.

In the tests made on this combination, both engine and dynamo were worked to a somewhat higher load than their normal or specified load, and this no doubt would to a slight extent favourably affect the efficiency. Another test was made on a similar combination working at its normal load, with the following results :—

Resistance of armature	...	0·0058 ohms.
Resistance of magnets	...	15·6 ohms.
I.H.P.	...	85·3
E.H.P.	...	70·0
Hence efficiency		83·3 per cent.

The electrical losses in the first instance are :—

Loss in magnet coils	...	756 watts =	1·4 per cent.
Loss in armature	...	1,386 watts =	2·6 „
Hence electrical efficiency	...	...	96·0 per cent.



From this it follows that the loss in friction in the engine and dynamo combined is 10 per cent.* of the indicated horse-power.

Messrs. Mather and Platt have constructed a large number of dynamos for combination with the Willans engine. Those referred to above are part of a number constructed to the order of Mr. Hargreaves for the City installations of Messrs. Spiers and Pond. Others of a considerably larger output are in progress for Messrs. Gatti's central station in the Strand, and for the Westminster Electric Supply Corporation, Limited, installations.

City Electric Lighting.—We beg to call the attention of electric lighting contractors to the advertisement in our business columns emanating from the City Commissioners of Sewers with regard to the City lighting.

* How is this percentage arrived at?—EDS. ELEC. REV.

THE NEW WEST INDIA CABLES.

THE ss. *Westmeath*, chartered for the laying of the new cables which are to connect certain of the West India islands with various points on the continent of South America, left Messrs. Henley's works at North Woolwich on October 15th.

It will be remembered that the *Westmeath* was employed for the laying of the Bermuda-Halifax cable, and on that occasion she was fitted with cable machinery and tanks, which, with some modifications, have been retained as originally designed. The vessel was built at Sunderland in 1882, is classed A 1 at Lloyds, her carrying capacity is 4,400 tons, her length 320 feet, beam 42·4 feet, depth of hold 28 feet, and H.P 300 nominal. She is said to be a very comfortable boat, extremely steady in a sea way, and possessing unusually good accommodation.

A large party met on board the ship at Greenhithe, on October 16th. Among those present were—M. Jules Lair, president; M. Paul Wallerstein, general administrator; and M. Ernest Vlasto, director and manager of works of the French Telephone Company. The works company was represented by Mr. Sutton, general manager, and Mr. Hatton, manager of works. Among the actual members of the expedition are Mr. W. S. Seaton, to whom is entrusted the entire direction of the work; Mr. Theophilus Smith, chief of staff; Mr. E. W. Stallibrass, engineer; and Mr. Hall, of Messrs. Henley's, chief electrician.

The total complement on board amounts to 106 persons, viz. :—Staff, officers, and engineers, 22; cable hands and mechanics, 40; crew, stewards, &c., 26; firemen, &c., 13; representatives of the Telephone Company and passengers, 5.

The cable taken out, 1,021 nautical miles weighing 2,558 tons, was manufactured by Messrs. Henley's for the

Société Française des Télégraphes Sous-Marins, who are also the proprietors of the cables laid, by the *Roddam* in 1888, between Cuba, Hayti, Santo Domingo, Curaçao, and Venezuela. A portion of the core was made by the French Telephone Company in their works at Bezons; it was shipped to England, and sheathed at Henley's.

The types of cable and their respective weights per nautical mile are as follows:—Shore end, 8·6 tons; heavy intermediate, 6·05 tons; light intermediate, 3·75 tons; and main cable, 1·72 tons. The core is composed of 130 lbs. of copper (seven strand) and 150 lbs. of gutta-percha per nautical mile.

The sections to be laid on the present expedition are:—

1. Island of Martinique to Paramaribo (Dutch Guiana). Approximate length about 685 N.M.

2. Paramaribo towards Cayenne (French Guiana). This section will not be completed on the present occasion. So much cable as can be be devoted to this section will be laid, the end buoyed, and cable completed on the next trip.

3. Mole St. Nicolas, Hayti, to Port-au-Prince, Hayti. Approximate length about 106 N.M.

The sections to be laid on one or more subsequent expeditions are:—

1. Completion of section between Paramaribo (Dutch Guiana) and Cayenne (French Guiana). Approximate length about 252 N.M.

2. Cayenne to Vizeu, Brazil. Approximate length about 575 N.M.

3. Puerto Plata, Island of Santo Domingo, to Island of Martinique. Approximate length about 670 N.M.

The total length of the new cables, including stock, will be somewhere about 2,500 N.M.

It will be remarked that the new cables will place the system owned by the Société Française des Télégraphes Sous-Marins, in direct communication with the Brazilian land lines at Vizeu. The company will thus have at one extremity (Santiago de Cuba) of their system communication with Europe *viâ* the cables of the Cuba Submarine Company, and at the other terminal (Vizeu) communication with the whole of the Brazilian Telegraph system.

It must be a source of considerable gratification, not only to the French telegraph and telephone companies, but also to the management of Messrs. Henley's, that the disasters, financial and otherwise, at one time freely predicted, have, at all events up to the present, been completely falsified. The French Telephone Company has evidently made considerable preparations for the extending its operations, for the new cable-sheathing works at Calais are not far off completion. It is expected that a good many orders will be received from the French Government. One drawback is, however, present in the manufacture of sheathed cables, in that the core is made at Bezons, and has to be transported to Calais to receive the sheathing. There is certainly but little difficulty in this transport, since a complete system of canals furnishes a cheap and ready method.

THE BREWERS' EXHIBITION AT THE AGRICULTURAL HALL.

THERE is not, as a rule, much attraction for electrical engineers at this class of show, and the present exhibition is much on a par with those that have preceded it. With the exception of the exhibits of five manufacturers of gas engines, and two small installations of the electric light, we did not observe any apparatus calculated to interest the electrical fraternity. But it is the duty of an electrical engineer to understand what he should avoid bringing his person in contact with, and notwithstanding there are no line wires to speak of at the Islington show, there are many temptations to sample liquid concoctions, which, in the form presented to the taster, are doubtless as deadly as any live wire conveying a high potential current. Two of the most dangerous of these abominations are to be specially guarded against, the one a bran new Irish whiskey, mechanically given the age of 10 years in about 10 minutes; to the taste bearing more resemblance to the fires proceeding from the abysmal depths than to genuine matured Jameson or Roe. The other bears the outward appellation of claret cup essence, but, in reality, is nearer akin to vitriol than to a pleasant summer beverage; the stuff slightly blistered our finger.

The most prominent show of gas engines is made by the manufacturers of the "Stockport" gas engine. The exhibit is the more noticeable from one of the engines driving a Paterson and Cooper dynamo, which supplies six arc lamps. It is claimed for the "Stockport" engine that it is still as economical as any in the consumption of gas, with an advantage on its side of lower cost of manufacture.

The Atkinson "Cycle" gas engine and the Crossley "Otto" gas engine are also exhibited by the respective manufacturers, but there was apparently nothing in either that could be noticed as improvements of recent date.

Messrs. S. Griffin & Co. have a novelty in a portable hydro-carbon gas engine. On the one frame is placed the usual gas engine and a generator for making gas from petroleum. Economy results from this arrangement, partly from the greater effect produced in the cylinder from ignited gas over the petroleum spray, as in other petroleum engines, and again from the saving of trouble and labour in keeping the machine clean.

The "Campbell" Gas Engine Company also run gas engines of their type, but this is somewhat similar to the "Stockport" in essential points.

Messrs. Harvey Graham show their "Ritter" patent self-acting lubricator for stationary, marine, and locomotive engines. It is worked by a simple mechanical motion from any moving part of the engine; consequently the feed is automatic, and when the engine stops the supply of oil ceases. It is claimed that there is in this machine absolute reliability in working, great saving in oil, and no noise in action.

REVIEW.

Rules for the Concentric Wiring of Buildings and Ships. By J. D. F. ANDREWS, M.I.E.E, A.M.I.C.E.

These rules are the outcome of the author's experience during many years practice as a specialist in the employment of concentric wiring, and he hopes that they will form a guide showing those interested in the introduction of the system the importance of carrying out the work in a uniform and substantial manner, applicable to a large systematic commercial business.

An advertisement on the cover sets forth the advantages of the concentric wiring over the two-wire system, and claims a greatly reduced fire risk, for the reason, as the author elsewhere states, that although electric lighting is undoubtedly safer than any other means of illumination, still many fires have taken place, the causes of which have been a source of study and discovery to many minds, with the result that they have been traced to four causes: first, when the two wires are brought accidentally into contact with each other; second, when a bridge of poor conducting power forms between the two wires; third, when the wires get broken by accident or corrosion, and the electricity jumps across the gap; fourth, when any derangement takes place in the switches, fuses, or fittings whereby a loose contact is made. Of all these sources of danger in electric light apparatus and wiring there is only one—namely, the first, for which a special apparatus has been invented to check its effect. The name given to this contrivance is the fuse or cut-out, and it consists simply of a wire of metal which is easily fusible, and as it is the nature of electricity to generate heat in its conductors, this wire, which forms part of the conductor

to the light, fuses, if the current passing increases to an excess, which is what takes place when the two conductors are accidentally brought into contact.

It has not been found possible with the existing practice of wood casing and two wires to make any provision against the other sources of danger, which really are the most serious. But by the system of concentric wiring these dangerous properties have been entirely set aside by a mode of construction, and the simplicity and substantial and durable character of electric lighting greatly enhanced. The wires used in this system are constructed one inside of the other, separated by an insulating substance. By this construction the conductors are arranged so near to each other that it is impossible for one of the wires to be deranged without affecting both, and causing that defect which is protected by the fuse. When any such accident does occur, it is contained within the surrounding tube conductor, and it only lasts for an instant.

It is also claimed that concentric wiring is cheaper in first cost than the two-wire system ; this we venture to doubt, providing that every particular and detail is constructed in accordance with Mr. Andrews's rules. Our opinion is supported by Mr. Rankin Kennedy, who says that the single wire system is more expensive to erect than the two-wire system, if the work be properly done.

Considerable care has been given to render the rules complete, so as to embrace all points that may arise in practice. From a note at the end, we also infer that they are satisfactory to the fire insurance companies ; the note states that installations carried out in accordance with the rules can be insured at the ordinary rates.

Some extra rules for ship lighting are appended, which should be valuable to those who are not much acquainted with electric work on board ship.

NOTES.

Telephony in the North.—It is reported that a deputation from Rothesay has called on Mr. Muirhead, whose name has of late come so much before the public in connection with the £4 per annum telephone company, and he has been asked to estimate for the erection of wires and the establishment of an exchange in Rothesay, to be fitted up with French instruments. The Postmaster-General is also being asked to grant a license to carry it on, on the usual terms.

Accident at a Paris Lighting Station.—Three firemen employed at the electric lighting "installation" at the Palais Royal, which supplies the Comédie Française and the neighbourhood around, were injured seriously at a late hour on Monday night by the explosion of a steam pipe connected with the engine. Many of the lights in the theatre were extinguished temporarily, but there was no interruption in the performance. On Tuesday evening one of the wounded men died.

A Curious Break in a Converter Primary.—A correspondent writing from Chicago to the New York *Electrical Engineer*, says :—I would call the attention of your readers to a sample of wire taken from the primary coil of a converter, which shows an apparently unaccountable break. The ends of the break are fused, while the insulation has not been charred except close to the break. There was nothing to show that this was caused by any cross with the secondary coil, or by any escape to ground. It is accepted by some people as being a freak of lightning, and has come to be such a common occurrence as to amount to a very serious trouble. I would like to enquire whether others have noticed this difficulty, and whether there is any good explanation to give except a fault in the copper finally resulting in a break.

Telephone Communication.—The introduction of the telephone to Campbeltown for business purposes is to take place this week, when a telephone is to be established between the Post Office and the shipbuilding yard. Several business firms in the town have already made enquiries with a view to the extension of the telephone system, and the establishment of an exchange at the Post Office.

Official Report on the Kemmler Execution.—Dr Carlos F. Macdonald, president of the State Commission in Lunacy, has furnished Governor Hill an official account of the recent death of William Kemmler, at Auburn Penitentiary, by electricity. He says :—"Compared with hanging, in which death is frequently produced by strangulation, with every indication of conscious suffering for an appreciable time on the part of the victim, execution by electricity is infinitely preferable, both as regards the suddenness with which death is effected, and the expedition with which all the immediate preliminary details may be arranged. By the latter method the fatal stroke renders its victim unconscious in an infinitesimal fraction of a second, so small as to be beyond the power of the human mind to estimate, while, at the same time, it disintegrates the nerve tissues and blood to an extent which insures an absoluteness of death in a shorter space of time than is possible by any other known method. In other words, it is the surest, quickest, most efficient, and least painful method that has yet been devised." Dr. Macdonald makes the following recommendations :—1. The statute providing for the execution of criminals by electricity should be amended so as to provide for but one plant, to be located in the central part of the state, in a building especially constructed for the purpose, the apparatus to be in charge of and operated by a competent, accredited electrician. 2. The engine and dynamo should be especially constructed for the purpose, and should be capable of generating an electromotive force of at least 3,000 volts, in order to insure the maximum voltage that would be necessary, and at the same time cause no injustice to any electrical lighting company, such as is likely to be the case so long as commercial dynamos are used in executing criminals. 3. The voltmeter should be located in the execution room, and a competent and responsible official should be detailed to take the readings of the meter before and at the instant the current is applied. The voltage should not be less than 1,500, nor more than 2,000, and should be a matter of official record. The prisoner's resistance should also be taken immediately before bringing him into the execution room.

Storage Cars.—There is yet a good time coming for the storage battery tramcar. The New York *Electrical Engineer* of the 15th inst. contained figures which show that as many storage cars are running to-day as there were of the overhead conductor system only two short years ago. In such a city as New Orleans, for example, the storage system is the only substitute for horses, and there, says our contemporary, it will achieve one of its greatest triumphs. The advocates of the secondary battery on this side will doubtless rejoice to think that the day is not far distant when the same progress will be shown in the United Kingdom.

Increased Business of the American Westinghouse Company.—The business of the Westinghouse Electric and Manufacturing Company has received an extraordinary boom during the last month. The shops are now running at their full capacity day and night, and the company has still orders ahead to keep it busy the entire winter. This large increase in the work is especially caused by the wonderful success of the street car motor lately brought out. The manufacture of alternating current apparatus has also gained considerably, and the new Westinghouse system of alternating current arc lighting is rapidly becoming a popular method of illumination.

Electric Light and Potential Differences.—Sir David Salomons has contributed to the October number of *Lippincott's* a treatise on electric lighting. It is, of course, of a popular nature, but the following extract may be of service to the ever-increasing race of primary battery inventors who will insist that their galvanic couples are pre-eminently suited to the requirements of electric lighting:—"A lamp (incandescent) intended to give a certain light with a given pressure would give less than half its light with a fall of 10 per cent. in pressure. On the other hand, a 4 per cent. increase of pressure above the normal would produce at least double the light intended." Primary batteries, therefore, intended for electric lighting become almost useless when the difference of potential at their terminals is allowed to fall below 10 per cent.

The Electric Lighting of Paris and Foreign Material.—*Le Matin* publishes the following remarks on the specification of charges of the electric lighting of Paris:—"One of the good results which the Municipal Council's specification of charges imposed on the concessionaires of sectors has certainly brought about has been to force foreign companies, which hitherto had imported their machinery and accessories to manufacture in France, which, as will be understood, is a very great advantage for French manufacturers and workmen. The most striking case is that American company, Babcock and Wilcox, the well-known makers of multitubular boilers. Though for four or five years this company has nearly wholly constructed its boilers in France, it only entirely carried them out in France when the Popp order was given to it. This company found itself, by the decision of the Municipal Council, before the alternative of refusing the order which had been given it—a large order of about 10,000 horse-power, intended for a large installation for the electric lighting of the city—or of entirely constructing it in France. The Babcock and Wilcox Company did not hesitate. It entered into an arrangement with Le Creusot, which undertook the construction of the Babcock and Wilcox boilers." From this summary of the facts, it will be seen that the Babcock and Wilcox Company found itself in an exceptionally difficult position, on account of the requirements of the Paris Municipal Council in regard to the secret construction of certain parts of its boilers. Nevertheless, the order was such an important one that a *tour de force* was necessary. The company rose to the situation, as may be judged from what precedes.

Electric Trains with Storage Batteries.—The practicability of working electric trains by means of storage batteries still remains an open question; but recently some continuous trials have been made on the Lehigh Avenue Street Railroad in Philadelphia, which appear to be of a satisfactory character, though the total time during which the trial has lasted is hardly sufficient to justify very sanguine hopes of the ultimate success of the system. On the track in question four cars have been operated continuously during the last four months with cells of the railroad type described in our leading pages. This road has numerous curves, and grades as heavy as 5½ per cent. These have taxed the cells to their utmost, the 100 cells on each car frequently being discharged at the rate of 45 electrical horse-power. During the month of August past, these cars alone carried 59,000 passengers, with frequent loads of 100 passengers on a car. The batteries have frequently made runs of 63 miles with a single charge under these conditions, thus giving a good indication of their increased efficiency where the conditions are more favourable as to grades and curves.

Fire at Boston Caused by Electricity.—It is said a fire, which broke out on Sunday last at the office of the Western Union Telegraph Company, was caused by an electric light wire crossing another wire. Work was temporarily suspended.

The Electrical Transmission of Power.—For the electrical power transmission installation near Grenoble the water is dammed so as to give an effective head of 230 feet, and is conducted by a steel pipe to the turbine. The generating dynamo is coupled directly to the horizontal shaft of the turbine, and is connected to the two cables by an aerial line, by which the power is transmitted to the motor at Montier, a distance of a little more than three miles. The following particulars are from *Le Genie Civil*:—Generator, 300 horse-power, 240 revolutions per minute; motor, 200 horse-power, 300 revolutions per minute; pressure, 2,850 volts; current, 70 ampères; resistance of line, 3·474 ohms; resistance of dynamo fields, 0·950 ohms; resistance of dynamo armature, 0·984 ohms; resistance of motor fields, 0·731 ohms; resistance of motor armatures, 0·690 ohms; total resistance of circuit, 6·829 ohms; electrical efficiency, 83 per cent.; mechanical efficiency, 65 per cent. This plant has been running since November last. Four men are employed—two at the generator and two at the motor—each being in attendance for twelve hours. A telephone line is run on the same poles as the working line. The line has been struck several times by lightning, but both generator and motor were fully protected. The power is used for driving a paper mill, and the cost is found to be much smaller than when steam was used.

Arc Lamps with Alternating Currents.—Mr. Steinmetz, of New York, is stated to have succeeded in effecting the feeding of 125 arc lights, Westinghouse pattern, by means of an equal number of small transformers connected in series on a circuit which carried a constant current of 30 ampères. Each lamp works at 50 volts and 10 ampères, so that for each lamp brought into circuit, the tension increases about 17 volts in the primary circuit, on which, however, it never exceeds 2,000 volts. The advantage of this system is the reduction of the potential in the lamp circuit, while a line at high tension is maintained. The lamps are the same as for continuous current, but with divided electromagnets. They are fitted with special flat and broad carbons, 20 cm. × 5 cm. × 0·8 cm. to 1·5 cm., having a durability of 40 hours. The Westinghouse-Stanley machine, which supplies the primary current, has a high self-induction owing to the induced coil being wound with a very large number of turns of wire, and consequently the current varies very slightly with external resistance, about 2 per cent. for tensions varying at the terminals from 1,000 to 3,000 volts. In order that the lamps should work under the best conditions, the speed of alternations of the current was reduced to one-half, the rate adopted being 130 complete periods per second.

Indurated Fibre for Conduits.—We read in the issue of the New York *Electrical Engineer* for September 17th that the use of indurated fibre pipes for underground telephone work has assumed considerable importance in Philadelphia. It is made by a patented process from long wood fibres, separated, washed free from all saps and gums, moulded while in a pulpy state into the requisite size and shape, and then subjected to great hydraulic pressure. After this it is treated and hardened by a special chemical process, so that it is rendered impervious to moisture or to the action of acids or gas. It is very tough and durable, and will withstand very great crushing strains. The tensile strength is about 1,100 lbs. to the square inch. Its weight is about one-fifth that of iron for equivalent service in pipe form. It will resist over 200° of heat, is insensible to the greatest cold, and is easily handled. For electric lighting purposes, the man-hole chambers are lined with the indurated fibre, the wires are led through to the pipes by means of rubber tubes, and the chamber is packed with phenicite, a plastic compound resisting moisture and high electrical temperatures. The joints and collars in the service pipes are also cemented with phenicite. The pipes are laid in a concrete of cement, sand, and gravel.

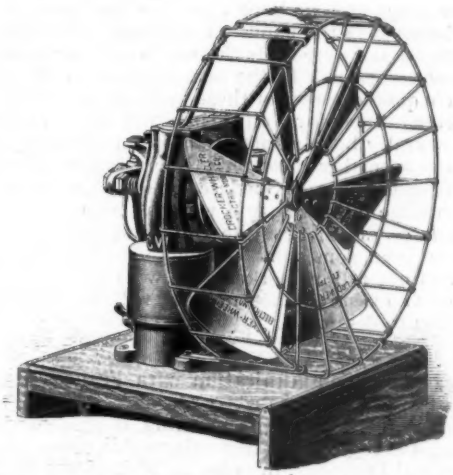
The Electric Tramcar Accident at Florence. — The following account of this unfortunate occurrence is taken from a letter to the *Standard*, and as it gives a pretty full description of the accident, may be worth reproduction for future reference :— The line (about 5 miles in length) is laid partly on one side, partly in the centre of the high road, winding, by a long loop, up the steep slope of the well-known Fiesole Hill, and is worked on Sprague's (American) system, by means of a somewhat complicated arrangement of overhead wires, which, owing to the numerous curves, and to the line changing from one side to the other, or being in the centre, are held in position by a series of additional wires, fixed to poles on one or both sides of the roadway. The two sharpest, almost semi-circular, curves occur at a distance of about half a mile from the summit level—viz., the Fiesole Terminus, one of these curves being less than two chains in radius, and the other being so sharp that, in order to avoid it, a back-shunt had to be adopted. The accident occurred on the first of these curves. A car containing 36 passengers (six more than the regulation number) left the summit, and the guard having by mistake failed to apply the current to the brake, the vehicle rushed unchecked, and with tremendous velocity, down an incline of 1 in 14 (7 in a 100), left the rails at the tangent of the curve, and rushed with terrific force against a parapet wall, five passengers being killed on the spot, and 20 more or less seriously injured. The immediate and avowed cause of the accident is said to be the negligence and inexperience of the brakesman, who was himself injured and placed under arrest; but, apart from the dangerously sharp curve referred to, it is difficult to see how an efficient and responsible staff, fit to deal with so powerful and sensitive a motor as electricity, can ever be found to work this line, when a brakesman, who on each journey has the lives of 30 passengers in his hands, receives the miserable wages of a little over two francs per day, and has to be on duty from 6 a.m. to 10 p.m. It is needless to say that the service on the line was at once and entirely stopped by the local authorities pending the inquiry into the accident, which will, moreover, entail on the company heavy compensation. It is a question whether, on a line of this nature, with steep grades and sharp curves, the rack system, or a combination of electric motive power and the rack, would not answer much better than electric power pure and simple, unless additional and independent brakes are provided to ensure safety."

Telegraph Cable Construction.—The *Times* has received the following communication from the Foreign Office :—A despatch has been received from her Majesty's Ambassador at Madrid, enclosing copies of a Royal decree authorising fresh tenders to be invited for the construction of the telegraph cables between the Peninsula and the Spanish possessions on the North Coast of Africa. The new conditions are slightly different from those referred to in the notice sent to the newspapers on the 23rd of August last from the Foreign Office. None of the tenders received in answer to the first application have been accepted. The conditions (in Spanish) may be seen at the commercial department of the Foreign Office, London, between the hours of 11 and 5.

Electric Light in the City.—The *City Press*, in a recent issue, raises the following query :—"Is it not time that some information should be given as to what steps are being taken with a view of carrying out the contracts for electric lighting of the City entrusted some months ago to the Brush Company and to the Thomson-Houston Co.? The contracts have, I believe, been signed, and there was a limit of time within which the works were to be completed, but so far as I know not the smallest commencement has been made. Indeed, rumour has it that in both instances subsidiary companies are about to be formed to undertake the business. At any rate we are entitled to know something of the matter."

Englishmen at Mr. Edison's.—A few days ago over 400 persons, comprising delegates to the meeting of the Mining Engineers and British Iron and Steel Institute, visited the Edison laboratory at Orange, N.J., where they obtained a peep at the famous workshops. Sir John Kitson and many well-known on this side of the water had an opportunity of chatting with Edison, who, an American paper says, derived great pleasure from the visit.

The Crocker Wheeler Motor.—These motors (of which we give an illustration) are essentially constructed for use with small currents on central station circuits. They are made from $\frac{1}{8}$th to 3 H.P., and can be put in circuit with either incandescent or arc lights. The want of such a motor made in a perfect style has been long felt in England, the motors that have already been supplied not giving satisfaction, mainly owing to want of care in the selection of material and the construction of details, and the success which the Crocker Wheeler motors have



achieved in the United States, there being over 2,000 installed in one year, is due to the perfect construction of the apparatus, its durability, and greater efficiency compared with its size. They are mainly used at present for pumps, fans, lifts, small machinery, &c., but when once introduced into England we have no doubt a great many uses will be found for them, and we think it especially in the interest of central stations to recommend the use of motors in order to make them known, and no doubt in time a considerable revenue will accrue from them. The sole agency for this country has been obtained by the General Electric Company, Limited.

Electric Lighting at Harecastle.—Messrs. Woodhouse and Rawson, of Kidsgrove, have just completed a very successful installation of the electric light at the Harecastle Hotel. The plant consists of a 110-volt dynamo, driven by a 10 H.P. engine, which supplies 90 16-C.P. lamps.

The Popularity of Electro-technics.—With reference to our Note under the above heading, we are informed that of the 596 students receiving technical instruction several hundreds are men already in the electrical industry who are engaged in electrical factories during the day, and who are therefore already provided for.

Electro-deposition.—Prof. Andrew Jamieson states that our calculations last week on the electro-deposition of copper exactly bear out his own figures at page 345 of the 6th edition of Munro and Jamieson's pocket-book, viz. :—1 lb. of pure copper deposited requires ·4 H.P. We might have added that this will be at least ·6 to ·8 H.P. indicated, taking everything into account. We hope that Mr. Jamieson may be able to endorse our further contribution to this subject.

The O. S. A.—On Friday evening last, the Old Students' Association of the City and Guilds of London Institute held their sixth annual dinner at the Holborn Restaurant, with Dr. Sumpner in the chair. Amongst the guests, we noticed the familiar faces of Profs. Perry and Silvanus P. Thompson, Mr. Kapp, Mr. A. P. Trotter, Mr. Biggs, Mr. Saunders, Q.C., Sir Owen Roberts, and others. Several good speeches, appropriate to the occasion, were made during the course of the evening, and these were alternated with songs and instrumental selections. The number of old students present did not adequately represent the strength of the Association; but we trust that through the energetic endeavours of Mr. W. B. Esson, the President-elect, Messrs. Reckenzaun, Albion Snell, and Reginald Jones (secretary), a new impulse will be given to the gatherings, whether for serious business or social enjoyment. Six years is not a very extended period upon which to form a judgment upon the future of the "Old Students," but we believe that, in view of the number of young men now studying for the electrical profession, such a body might develope into one of a highly useful nature in after years, and we hope that now the helm of the Association is in the hands of practical men who can understand and appreciate the wants of their members, the new session will be the turning point in the somewhat chequered career of these budding scientists and engineers. Success or failure in newly-formed societies may generally be attributed to those in office as much as to any special inducements which may be offered to intending members. Good leaders will always command a large following, and we shall now expect that *esprit de corps* amongst the Old Students which has hitherto been somewhat lacking. To the President-elect and his fellow-workers we wish all success, for we feel well assured that nothing will be wanting on their part to deserve it.

Telegraphic Communication with France.—A telegram from Paris, dated yesterday, says:—"At a Cabinet Council held this morning it was decided to sanction the laying of a new telegraphic cable between France and Denmark, in order to obviate the frequent interruptions of communication at present occurring between the two countries. The Ministers also decided to establish telegraphic connection between Marseilles and Tunis, and Marseilles and Oran.

The Whittingham Magazine Fuse.—To replace an ordinary cut-out fuse when burnt out it is necessary to perform several small operations which entail a certain amount of trouble, and there is, besides, a risk that the clamping of the wire to the frame may not be efficiently done. In the Whittingham cut-out (an American device) the burnt out fuse is replaced by simply turning a knob through a half revolution. The fuse wire is contained in a small non-conducting cylinder carrying on its spindle a spool on which is wound the fuse wire. On turning the cylinder a wedge-shaped flange or its periphery serves to open a spring jaw, and as the thick end of the flange leaves the clip the jaws come together and catch the end of the fuse protruding from the rear of the wedge. Another half turn of the knob causes the sharp end of the flange to enter between the jaws of the other clip and spread them apart as it passes. The end of the fuse being now held by the first clip, is drawn out from the spool as the cylinder is turned. When the revolution of the cylinder is completed both clips are in action and the fuse wire is firmly held. The convenience of this arrangement is undoubted, but the idea of a magazine fuse is not new, as we have the recollection of seeing such a device some six years back, the manipulation in replacing a burnt out wire was accomplished by the simple plan of opening and shutting the lid of the fuse box.

Whitby Applies for an Order.—The District Local Board of Whitby (Yorks) will apply to the Board of Trade for a provisional order.

Interesting to Engineers.—The Journal of the Franklin Institute for this month contains the first portion of a paper by Chief Engineer *Isherwood*, U.S.N., on "The Processes of Steam in its Development of Power by means of the Steam Engine." It is a reprint of the lecture delivered by this gentleman before the Sibley College of the Cornell University, Ithaca, N.Y., in December last. We also note a paper in the "Transactions of the American Society of Civil Engineers" for July last, and which has just come to hand, by Prof. Robert H. Thurston, entitled "A Practical Method for Reducing the Internal Wastes of the Steam Engine."

The Ferranti Mains.—It is stated that so much of the new cable is down and at work, that the induction effects, which so greatly troubled the Post Office authorities, have been quite elimated, and everything is now running well; we believe this statement is not yet borne out by facts, and is decidedly premature.

Strike of Telegraph Operators.—Some inconvenience was caused lately on the Mackay system in the United States by a strike amongst their operators, but it appears to have soon been terminated by the demands of the operators being granted in full. The demands were for increased wages, and a promise that only competent men would be employed. This latter request arose from the custom of telegraph pupils being employed to work for nothing until they become expert in the use of the instruments, when they generally offer to work at a certain station for $10 a month less than the ordinary operator is being paid for it.

Accumulator Explosions.—The *Daily Telegraph* of Tuesday had the following paragraph in "London Day by Day":—An extraordinary explosion took place the other day on board Earl Poulett's steam yacht, the *Pathfinder*, while lying in Portsmouth Harbour, but, fortunately, without injuring anyone. The vessel is lighted throughout with the electric light. Formerly the accumulators were stowed in the coal bunkers, but, as the spot was not easy of access, they were this season placed on deck, encased in lead and covered with teak. The dynamo was worked by a small boiler in the engine room, which also heated the water for general supply throughout the vessel. During a violent storm of rain the steward reported a leak in his cabin from the deck, and, on going to examine the cause, Lord Poulett discovered that the water came down the hole through which one covered wire passed from the accumulators and went to the dynamo. As it was rather dark, he struck a wax match, and immediately a terrific explosion took place, the yacht being shaken from stem to stern. On going on deck, Lord Poulett saw that the whole of the accumulators had exploded, blowing the teak cases to pieces, and sending the glass fragments and the splinters into the air. The dynamo was running at the time, and only ten minutes previously his lordship and the engineer had been examining the cells, with the lids of the cases open, to see in what state the acid was. Each cell had a vent-hole on the top for escape of air and for ventilation, so that how the explosion originated remains a mystery. The electricians declare it to be one of the most extraordinary things they have ever known, and can in no way account for it, as it has hitherto been thought that under no circumstances could gas be generated in accumulators. It would be satisfactory, therefore, if scientific men could find some solution to the problem, otherwise launches and yachts, where electricity is employed, will be looked upon as too dangerous for holiday cruising.

Subway Rentals.—The electric light companies complain that the rental for ducts in the new subways in New York are prohibitive, that some companies are being illegally favoured, and that there is no way of deciding the matter except by appeal to the law courts.

The Institution of Civil Engineers.—Amongst the subjects suggested for papers for the forthcoming session of this Institution are the following:—"The Lighting of Railway Carriages by Oil, Gas, and Electricity Compared;" "Electrical Traction for Roads and Railways;" "The Design and Arrangement of Electric Supply Stations and of Electric Distributing Apparatus for Domestic, Trade and General Service in Towns, particularly as to Economy and Safety;" "The Comparative Advantages of Gas and Electricity for Lighting Purposes;" "The Application of Electricity to Bleaching;" "Electric Mining Machinery for Pumping, Hauling, and Coal-Cutting in Mines and Collieries;" "The Application of Electricity to Smelting and Metallurgical Operations;" "The Electro-Deposition of Copper;" "The Cost of the Production and Distribution of Electrical Energy;" "The Distribution and Application of Electric Power in Towns;" "Electrical Measuring Instruments, such as Ammeters, Voltmeters, Power-Meters, and Supply Meters."

National Telephone Company, Limited, Glasgow District Electrical Society.—This society was inaugurated on Thursday evening, the 16th inst., D. Kinross, cashier of the company, presiding. The office bearers and committee of management were appointed for the ensuing session. The first paper of the session was read by Mr. Aitken, district engineer of the company, his subject being "The Exchange." He recommended single core for all non-multiple boards for compactness and speedy operating. His paper was very interesting and instructive, and was well received by a large gathering of the *employés*.

NEW COMPANIES REGISTERED.

Petronite Syndicate, Limited.—Capital £6,060, in £1 shares. Object: To adopt an unregistered agreement of 1st October, entered into with Wm. Sinclair, of Hull. To acquire and work patents, inventions and secrets relating to the preparation of enamel, varnish, damp coursings, insulators, coating for submarine cables, &c. Signatories (with 1 share each), F. Gordon Pape, Wm. Gillyott, C. Muirhead, *G. Bohn, *D. W. Sissons, J. B. Willows, and T. H. Sissons, all of Hull. The signatories denoted by an asterisk, and R. Barton and Thos. Bailey, are the first directors. Qualification, £100 in shares stock. Remuneration, £10 10s. each per annum, and, in addition, 10 per cent. on all moneys received on the sale of all or any of the patents or secrets of the company. Registered office, Cogan House, Bowl Alley Lane, Hull. Registered 16th inst. by J. A. Jackson and Son, Hull.

Electro-Chemical Syndicate.—Capital £5,000, in £1 shares. Objects: To acquire and develop patents, and to carry on any business, whether manufacturing or other, in connection with the working of the same; to acquire or to construct engines, machinery, and appliances of all kinds. Signatories (with 1 share each): C. C. Marriott, 57, Lavender Sweep, S.W.; T. Trunmell, Monument Buildings; G. W. Crosby, 20, Abchurch Lane; G. Fumey, Dashwood House; A. Bissland, 4, Copthall Buildings; J. H. Waldock, 16, Chadwick Road, Peckham; E. J. Wills, 46, Mortimer Street, W. Registered 16th inst., without special articles of association, by Lovell and Trunmell, Monument Buildings, E.C.

British Insulated Wire Company, Limited.—Capital £60,000 in £5 shares. Objects: To manufacture and deal in wire, wire ropes and cables of all kinds, and to carry on business as electricians and as manufacturers of and dealers in electrical apparatus. Signatories (with 1 share each): J. B. Atherton, J. Atherton, Huyton, Lancashire; T. P. Hewitt, S. H. Hartley, Prescot; W. E. Brigg, Keighley, York; J. H. Dodd, Liverpool; J. Beckett, Huyton. The signatories are to appoint the first directors, remuneration £200 per annum, and in addition 10 per cent. of the nett profits remaining after payment of 10 per cent. per annum dividend on the ordinary shares. Registered 20th inst. by T. T. Hall, 22, Chancery Lane; solicitors, J. and H. Gregory, Leslie and Hartley, Liverpool.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Schanschieff Electric Light and Power Company, Limited.—At a general meeting of this company, convened by the liquidators, and held at 32, Poultry on the 17th inst., the accounts of the liquidators, showing the manner in which the winding-up of the company has been conducted and its property disposed of, were laid before the meeting, and were approved and adopted. It was further resolved that the accounts, books, and documents of the company may be destroyed after the lapse of three months.

National Telephone Company, Limited.—The annual return of this company, made up to the 12th July, was filed on the 17th inst. The nominal capital is £4,000,000, divided into 740,000 ordinary shares of £5 each, 15,000 first preference shares of £10 each, and 15,000 second preference shares of £10 each. The shares taken up are as follows: 438,984 ordinary, upon which the full amount has been called; 15,000 first preference, upon which the full amount has been called; and 15,000 second preference, upon which £8 per share has been called. The calls paid upon ordinary shares amount to £2,194,920, upon first preference £150,000, and upon the second preference to £120,000.

Andrews and Preece, Limited.—The statutory return of this company, made up to the 14th August, was filed 10th ult. The nominal capital is £25,000 in £10 shares, 300 of which are deferred shares; 599 shares are taken up, 300 and 226 ordinary being considered fully paid. Upon 73 ordinary shares £5 per share has been called up, the calls paid amounting to £345, and unpaid to £20.

Thorneburry Miners' Safety Lamp Company, Limited.—The statutory return of this company, made up to the 17th ult., was filed on the day following. The nominal capital is £50,000, in £1 shares. 30,050 shares are taken up, 20,540 of which are considered as fully paid. Upon 7,480 shares 15s. per share has been called, and upon 2,030 the full amount. The calls paid amount to £6,968, and unpaid to £672.

CITY NOTES, REPORTS, MEETINGS, &c.

Eastern Extension, Australasia and China Telegraph Company, Limited.

The following report and accounts for the half-year ended 30th June, 1890, was submitted to the thirty-fourth ordinary general meeting, 22nd October, 1890, held on Wednesday last, at Winchester House, Sir John Pender in the chair.

"The usual statements of account for the half-year ended 30th June, 1890, are herewith submitted.

"The gross receipts, including Government subsidies, have amounted during that period to £254,856 18s. 10d. against £256,757 3s. 2d. for the corresponding half-year of 1889.

"The working and other expenses, including £24,508 3s. 10d. for cost of repairs to cables and expenses of ships, absorb £76,670 9s. 3d. against £73,773 10s. 2d. for the corresponding period of 1889, leaving a balance of £178,186 9s. 7d. From this is deducted £2,960 19s. 7d. for income tax, and £38,549 14s. 7d. for interest on debentures and contributions to sinking funds, leaving £136,675 15s. 5d. as the net profit for the half-year. Against this £1,642 11s. 11d. has been charged for additions to staff quarters, and £712 16s. 1d. for expenses in connection with the recent Paris International Telegraph Conference, leaving an available balance of £134,320 7s. 5d.

"One quarterly interim dividend of 1¼ per cent., amounting to £31,250, has been paid during the half-year, and another of like amount will be distributed on the 15th instant, leaving £71,820 7s. 5d. to be carried forward.

"The duplication of the New Zealand cable, and the partial renewal of the Madras-Penang section referred to in the last report have been successfully carried out during the half-year under

review, and the cost, amounting to £188,433 15s. 6d. and £80,848 1s. 3d. respectively, has been charged to the general reserve fund, which, after being credited with the profit of £21,103 3s. 4d. made on the sale of investments, and the interest received during the half-year, now stands at £472,713 15s. 3d.

"The subsidy granted by the Spanish Government in respect of the Manila cable expired on the 1st May last, when the balance of the 5 per cent. debentures issued to provide the capital for this cable was paid off, and as the interest and sinking fund contributions have now ceased, there will in future be a saving of revenue on this account of about £5,000 per annum.

"The company's £320,000 six per cent. debentures mature for payment at par on the 1st February, 1891, and your directors have decided to pay them off on that date by issuing a similar amount of 4 per cent. mortgage debenture stock. An extraordinary general meeting will be held immediately after the ordinary meeting at which the necessary resolution will be submitted for the shareholders' approval.

"Negotiations have been entered into with the Governments of Australasia for the establishment of reduced rates to Australia and New Zealand, and the matter is now under consideration in the colonies.

"Arrangements have also been made with the Indian Government for improving the International service; in connection with which the company has decided to duplicate the Madras-Penang cable, and a contract has accordingly been entered into with the Telegraph Construction and Maintenance Company for carrying out the work, which is expected to be completed early next year.

"During the half-year the Tonquin-Hongkong section has been partially renewed by the insertion of 67 nautical miles of new cable, and the operation will be continued as opportunities occur until the line is put into good order.

"The company's maintenance ships have been employed on various cable repairs, but no interruptions materially affecting the revenue have occurred during the past six months. Unfortunately, however, since the close of the half-year telegraphic communication with Australia has been totally interrupted, from the 11th to the 20th July, in consequence of the sudden and simultaneous breaking, through volcanic action, of the three Java-Australian cables near Banjoewangie (Java). This was the more disappointing as it was only last year that the cable to Western Australia was laid mainly with a view to averting such a contingency, but as only two interruptions from volcanic causes have been experienced during a period of nearly 20 years, it is hoped that the cables will now have a long immunity from further trouble of this nature."

The CHAIRMAN, after going over the figures in the report, said the increase in working expenses was accounted for by the fact that the repairs had been heavier than the corresponding period of last year. The laying of the duplicate cable between Australia and New Zealand had since the last meeting been successfully completed, also a partial renewal of the Madras-Penang section; the cost of the two operations had been debited to revenue account. He had often had occasion to explain to them that the object of the company was to keep down capital and keep the system in thorough repair; in that way satisfactory dividends were obtained, and a goodly sum placed to the reserve. On account of the Manila subsidy arrangement having expired and the paying off the capital required for this cable, the company would save about £5,000 a year. The 6 per cent. debentures would be shortly changed to 4 per cent. debentures; a resolution to this effect would be brought before them at the close of the present meeting. Passing on to the question of cable renewals, it was a necessity to have duplication, so that the revenue would never be disturbed. Unfortunately they had nine days' interruption on their cables to the Australian colonies, although they had three cables at work; this was caused by an earthquake. Although rare, a similar occurrence to this happened about 20 years ago; this showed the importance of duplicating even with three cables. It was in one sense unfortunate, though in another it was satisfactory to see how soon repairs could be effected. All these things led him to think that there was no company in the world which could compete with them. That was their strength; they were not monopolists, for they had no exclusive concessions, but they had gradually built up their position, and now they were impregnable. Coming now to the subject of the reduced tariff to Australia, the speaker said there had been a great deal of discussion. The present tariff, 9s. 4d., was reduced by them from 10s. 8d. five years ago. They were fully recouped for the temporary loss in about three years. Another agitation had now begun for a further reduction. Conferences were held with the Agents-General in London, men who were eminently qualified to look after the interests of the Colonies, and with them they resolved, in face of the increasing vitality in the merchant life of Australia and a guarantee from the Government, to reduce their charge to 4s. So confident did the board feel of the success of the scheme, that they were taking half the risk. The increased income to the company would more than justify that action, and at the next meeting they would be able to speak of the success of the scheme. Speaking of the Paris Conference, he would remind honourable shareholders that they anticipated things would go rather hard with them; such had not been the case, however, and they came out of the Conference unscathed. In conclusion, the speaker dwelt with satisfaction on the arrangement made with the Indian Government as to cable work in that part of the world.

The report was then formally moved and seconded.

A few questions were satisfactorily disposed of, and the report and accounts were adopted.

At the conclusion of the ordinary business, an extraordinary general meeting was held for the purpose of considering the following resolutions:—

(*a.*) "That the board of directors be, and are hereby authorised from time to time to create and issue mortgage debenture stock of the company to an amount not exceeding one-third of the share capital of the company for the time being issued and paid up, upon the terms that the aggregate amount of the said stock for the time being in issue, and the interest thereon, shall rank *pari passu* as a first charge on the undertaking and revenue of the company, the stock to be issued at such times, in such amounts, and on such terms and conditions as the board shall from time to time determine, for the purpose of redeeming by exchange or otherwise the outstanding debentures of the company, or any other purpose to which capital of the company may be lawfully applicable."

(*b.*) "That the board be, and are hereby authorised to make such provision as they think fit for the registration and transfer of mortgage debenture stock, and for the delivery of certificates thereof, and for the payment of the interest thereon, and generally as to the form and incidents of all documents relating to the said stock, but so that no such provision be inconsistent with paragraph (*a*) of this resolution."

These were carried unanimously, and the meeting dispersed.

Brazilian Submarine Telegraph Company, Limited.

THE thirty-fourth ordinary general meeting was held at Winchester House, on Wednesday, under the presidency of Viscount Monck, who in his address remarked that the working of the company was satisfactory. They had paid a dividend of 7½ per cent., added £40,000 to the reserve fund, and paid off debenture debts to the amount of £15,300, which was shown in the report published in the REVIEW last week. There were favourable indications, so far, for the next half-year. Notwithstanding a satisfactory evidence of the state of things, they had undoubtedly a rock ahead of them, which was the termination of their concession, and which would run out in two years or a little over. Many things were being done, and he could assure them that the board watched the interests of the company with increasing vigilance as the time arrived for proper action. At the last meeting, observations were made with reference to statements in the original prospectus of the company. This was a subject on which he was very sensitive, as he was then, as now, chairman, and practically responsible for that prospectus. Of the feeling and disposition of the gentleman who made the remark towards the board he had not a word to say, as the utmost good feeling prevailed. He said truly that there were statements made with reference to a probable yield of 14 per cent. Now what they did on that occasion was an endeavour to establish a relation between the general mercantile movement in the kingdom and telegraphic communication. They did this on the experience of others; figures were quoted which were open to all. They said that the trade to and from the Brazils might be expected to yield 15 per cent.; it had nearly reached that point, and if they considered everything that had been done, he (the speaker) thought the management was open to little objection. During the period of their existence, 16 or 17 years, they had never paid dividends less than 5 per cent., while on some occasions they had reached 7½ per cent. The whole of the system had been duplicated out of revenue, and if the whole of the debentures raised for that purpose were now paid off there would still be a sum of £2,000 for reserve. The plant was in excellent order; the lines were working well; the receipts for the half-year showed an increase on the previous half-year. A decrease in the London expenditure was accounted for by the absence of law charges. An item in the account which was very large was the laying of land lines, which was not likely to occur again. In conclusion, the chairman referred to the death of Dr. Taylor, their Brazilian representative, whose place had now been filled.

Retiring directors and auditors being re-elected, the proceedings terminated.

The Consolidated Telephone Construction and Maintenance Company, Limited.—This company has declared an interim dividend for the half-year at the rate of £6 per cent. per annum on the preference shares and £5 per cent. per annum on the ordinary shares, both less income tax, payable on November 14th.

West India and Panama Telegraph Company.—The board recommend a payment of 6s. per share to June 30th last on the first preference shares, and £3 per share on account of arrears on the second preference shares. The sum of £1,500 is to be placed to reserve, leaving a balance of £322.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 17th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,542.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending October 17th were £4,891

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (October 16).	Closing Quotation. (October 23.)	Business done during a week ending October 23, 1890. Highest.	Lowest.
250,000*l*	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	99 —102		
1,549,160*l*	Anglo-American Telegraph, Limited	Stock	49½— 50½xd	49 — 50 xd	50½	49½
2,725,420*l*	Do. do. 6 p. c. Preferred	Stock	85 — 86 xd	85 — 86 xd	85½	85
2,725,420*l*	Do. do. Deferred	Stock	13⅜— 14½	13 — 13½	13⅜	...
130,000	Brazilian Submarine Telegraph, Limited	10	11⅞— 12⅛	11⅞— 12⅛	12 3/16	11⅞
84,500*l*	Do. do. 5 p. c. Bonds...	100	100 —102	100 —102		
75,000*l*	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	103 —107	103 —107		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1½— 1⅝	1½— 1⅝	1 7/16	...
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1½— 2	1½— 2		
$7,216,000	Commercial Cable, Capital Stock	$100	102 —104	102 —104		
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	⅛— ¼	⅛— ¼		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5½— 5¾	5½— 5¾		
16,000	Cuba Telegraph, Limited	10	11½— 12	11½— 12		
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	3¾— 4¼xd	3¾— 4¼xd	4	3¾
6,090	Do. do. 10 p. c. Preference	5	9 — 10	8½— 9½xd	9	...
60,710	Direct United States Cable, Limited, 1877	20	10⅜— 10⅝	10⅜— 10⅝	10⅝	10 5/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	13¾— 14⅛xd	13¾— 14⅛xd	14⅛	13¾
70,000	Do. 6 p. c. Preference	10	14¾— 15½	14¾— 15½xd	14¾	...
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109		
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	104 —107	104 —107		
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	14 — 14¼xd	14⅛— 14⅜xd	14¼	14
320,000*l*	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	100 —102		
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg.	100	102 —105	102 —105	101⅛	...
325,200*l*	Do. 5 p. c. Debentures, 1890, redeem. ann. drgs. to bearer	100	102 —105	102 —105	102½	...
145,300*l*	Eastern and South African Tel., Ld., 5 p. c. Mort. Deb., 1900 reg.	100	101 —104	101 —104		
198,200*l*	Do. do. do. to bearer	100	... ...	101 —104		
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7⅛— 8	7⅛— 8	7⅛	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4¼— 5⅛	4¼— 5⅛		
70,000	Elmore's Patent Copper Depositing, Ltd., Nos. 23,001 to 70,000	2	5 — 5⅛	5 — 5⅛	5⅛	4¾
67,385	Elmore's Wire Manufacturing, Limited, Nos. 1 to 67,385 issued at 1 pm. all paid (£1¼ paid)	2	2 — 2⅛	1¾— 2¼		
20,000	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£3 only paid)	5	3½— 4	2½— 3		
180,227	Globe Telegraph and Trust, Limited	10	8¼— 9⅛	9 — 8 13/16	9	8 13/16
180,042	Do. do. 6 p. c. Preference	10	14¾— 15	14¾— 14¾	14¾	14¾
150,000	Great Northern Tel. Company of Copenhagen	10	15¾— 16½	15¾— 16½	16½	13¾
15,000*l*	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	101 —104	101 —104		
230,000*l*	Do. do. do. (issue of 1883) ...	100	104 —107	104 —107		
9,334*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11½— 12½	11½— 12½		
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11½— 12½	11½— 12½		
41,609	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19	18 5/16
200,000*l*	Do. do. 4½ p. c. Deb., 1896...	100	100 —102 xd	100 —102		
17,000	Indo-European Telegraph, Limited...	25	36 — 38	36 — 38		
38,348	London Platino-Brazilian Telegraph, Limited	10	6¼— 7⅛	6¼— 7⅛		
100,000*l*	Do. do. do. 6 p. c. Debentures ...	100	105 —108	105 —108		
43,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 ...	10	5½— 6	5 — 5¼	5¼	5⅛
438,984	National Telephone, Limited, Nos. 1 to 438,984	5	4⅜— 4⅝	4⅜— 4⅝	4⅝	4⅜
15,000	Do. 6 p. c. Cum. 1st Preference	10	12½— 12⅝	12 — 12⅛		
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	9½— 10⅛	9½— 10⅛		
2 20,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ⅜	⅛— ⅜		
9,000	Reuter's, Limited	8	8¼— 8⅜xd	8¼— 8⅜xd	8¼	...
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ...	⅛— ...		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	113 —117	113 —117		
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	5½— 5¾	5½— 5¾	5½	5½
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45	45	44
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
58,000	United River Plate Telephone, Limited	5	3½— 4	3 — 4		
146,128*l*	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 94	90 — 94		
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8½— 9½	8½— 9½		
290,900*l*	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101		
30,000	West Coast of America Telegraph, Limited	10	4½— 5	4½— 5	4¾	4½
150,000*l*	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	102 —107	102 —107	103½	103
64,174	Western and Brazilian Telegraph, Limited	15	11½— 11⅝	11 — 11½	11½	11⅜
27,873	Do. do. do. 5 p. c. Cum. Preferred	7⅛	6¾— 7⅛	6¾— 7	6 31/16	6¾
27,873	Do. do. do. 5 p. c. Deferred	7⅛	4¾— 5⅛	4½— 5		
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	2¾— 3⅛	3 — 3¼	3 1/16	3
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	11¾	11½
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	14 — 15	14 — 15		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	122 —127	122 —127		
175,100	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£3 only paid)	5	2½— 3	2 15/16— 3		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅝.—Elmore Copper Depositing Priorities, 7 —7¼.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, 15s. paid), 1¼—1½.—House-to-House Company (£5 paid), 5 —5¼.—International Okonite, Ordinary of £10 (£7 paid), 6⅞—7¼.—London Electric Supply Corporation, Ordinary (£5 paid) 2⅜—2⅝.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.

BANK RATE OF DISCOUNT.—5 per cent. (25th September 1890).

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 471.*)

Let me show you yet another experiment. This is the same electro-magnet (fig. 24) which has one flat pole and one rounded pole. Here is an armature, also bent, having one flat and one rounded pole. If I put flat to flat, and round to round, and pull at the middle, the flat to flat detaches first; but if we take round to flat, and flat to round, we shall probably find they are about equally good—it is hard to say which holds the stronger.

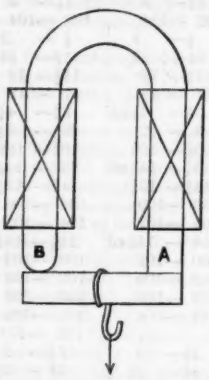


FIG. 25.—EXPERIMENT OF DETACHING ARMATURE.

The law of traction can again be applied to test the so-called distribution of free magnetism on the surface. This is a subject on which I shall have to say a good deal. We must therefore carefully consider what is meant by the phrase. Let fig. 26 be a rough drawing of an ordinary bar magnet. Every one knows that if we dip such a magnet into iron filings the small bits of iron stick on more especially at the ends, but not exclusively, and if you hold it under a piece of paper or cardboard, and sprinkle iron filings on the paper, you obtain curves like those shown on the diagram. They attest the distribution of the magnetic forces in the external space. The magnetism running internally through the body of the iron begins to leak out sideways, and finally all the rest leaks out in a great tuft at the end. These magnetic lines pass round to the other end, and there go in again, and the place where the steel is internally most highly magnetised is this place

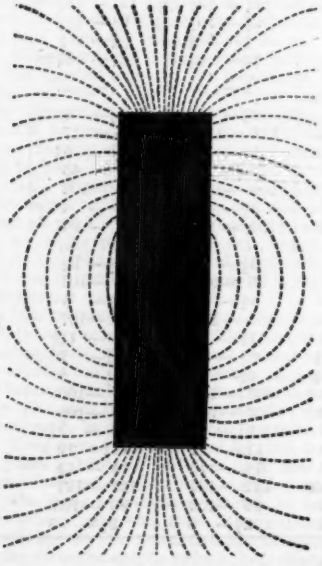


FIG. 26.—LINES OF FORCE RUNNING THROUGH BAR MAGNET.

across the middle, where externally no iron filings at all stick to it. Now we have to think of magnetism from the inside and not the outside. This magnetism extends in lines, coming up to the surface somewhere near the ends of the bar, and the filings stick on wherever the magnetism comes up to the surface. They do not stick on at the middle part of the bar, where the metal is really most completely permeated through and through by the magnetism; there are a larger number of lines per square centimetre of cross section in the middle region where none come up to the surface, and no filings stick on. Now, we may explore the leakage of magnetic lines at various points of the surface of the magnet by the method of traction. We can thereby arrive at a kind of measure of the amount of magnetism that is leaking, or, if you like to call it so, of the intensity of the "free magnetism" at the surface. I do not like to have to use these ancient terms, because they suggest the ancient notion that magnetism was a fluid or, rather, two fluids, one of which was plastered on at one end of the magnet, and the other at the other, just as you might put red paint or blue paint over the ends. I only use that term because it is already more or less familiar. Here is one of the ways of experimentally exploring the so-called distribution of free magnetism. The method was, I believe, originally due to Plücker; at any rate, it was much used by him. This little piece of apparatus was arranged by my friend and predecessor, Prof. Ayrton, for the purpose of teaching his students at the Finsbury College.* Here is a bar magnet of steel, marked in centimetres from end to end; over the top of it there is a little steel-yard, consisting of a weight sliding along an arm. At the end of that steel-yard there is suspended a small bullet of iron. If we bring that bullet into contact with the bar magnet anywhere near the end, and equilibrate the pull by sliding the counterpoise along the steel-yard arm, we shall obtain the definite pull required to detach that piece of iron. The pull will be proportional, by Maxwell's rule, to the square of the number of magnetic lines coming up from the bar into it. Shift the magnet on a whole centimetre, and attach the bullet a little further on; now equilibrate it, and we shall find it will require a rather smaller force to detach it. Try it again, at points along from the end to the middle. The greatest force required to detach it will be found at the extreme corner, and a little less a little way on, and so on until we find at the middle the bullet does not stick on at all, simply because there are here no magnetic lines leaking. The method is not perfect, because it obviously depends on the magnetic properties of the little bullet, and whether much or little saturated with magnetism. Moreover, the presence of the bullet perturbs the very thing that is to be measured. Leakage into air is one thing; leakage into air perturbed by the presence of the little bullet of iron, which invites leakage into itself, is another thing. It is an imperfect experiment at the best, but a very instructive one. This method has been used again and again in various cases for exploring the apparent magnetism on the surface. I shall use it hereafter, reserving the right to interpret the result by the light of the law of traction.

I now pass to the consideration of the attraction of a magnet on a piece of iron at a distance. And here I come to a very delicate and complicated question. What is the law of force of a magnet —or electro-magnet—acting at a point some distance away from it? I have a very great controversy to wage against the common way of regarding this. The usual thing that is proper to say is that it all depends on the law of inverse squares. Now, the law of inverse squares is one of those detestable things needing to be abolished, which, although it may be true in abstract mathematics, is absolutely inapplicable with respect to electro-magnets. The only use, in fact, of the law of inverse squares, with respect to electro-magnetism, is to enable you to write an answer when you want to pass an academical examination, set by some fossil examiner, who learned it years ago at the University, and never tried an experiment in his life to see if it was applicable to an electro-magnet. In academical examinations they always expect you to give the law of inverse squares. What is the law of inverse squares? We had better understand what it is before we condemn it. It is a statement to the following effect—that the action of the magnet (or of the pole some people say), at a point at a distance away from it, varies inversely as the square of the distance from the pole. There is a certain action at one inch away. Double the distance; the square of that will be four, and, inversely, the action will be ¼; at double the distance the action is ¼; at three times the distance the action is ⅑, and so on. You just try it with any electro-magnet; nay, take any magnet you like, and unless you hit upon the particular case, I believe you will find it to be universally untrue. Experiment does not prove it. Coulomb, who was supposed to establish the law of inverse squares by means of the torsion balance, was working with long thin needles of specially hard steel, carefully magnetised so that the only leakage of magnetism from the magnet might be as nearly as possible leakage in radiating tufts at the very ends. He practically had point-poles. When the only surface magnetism is at the end faces, the magnetic lines leak out like rays from a centre, in radial lines. Now the law of inverse squares is never true except for the action of points; it is a "point" law. If you could get an electro-magnet or a magnet, with poles so small in proportion to its length that you can consider the end face of it as the only place through which magnetic lines leak up into the air, and the ends themselves so small as to be relatively mere points; if, also, you can regard those end faces as something so far away from whatever they are going to act upon that the distance between them shall be large compared with their size, and the end itself so small as to be a point, then, and then only, is the law of inverse squares true. It is a law of the action of points. What do we find with electro-magnets? We are dealing with pieces of iron which are not infinitely long with respect to their cross section, and generally

* Cantor Lecture. Delivered before the Society of Arts, January 27th, 1890.

* See Ayrton's *Practical Electricity*, fig. 5a, p. 24.

possessing round or square end faces of definite magnitude, which are quite close to the armature; and which are not so infinitely far away that you can consider the polar face a point as compared with its distance away from the object upon which it is to act. Moreover, with real electro-magnets there is always lateral leakage; the magnetic lines do not all emerge from the iron through the end face. Therefore, the law of inverse squares is not applicable to that case. What do we mean by a pole, in the first place? We must settle that before we can even begin to apply any law of inverse squares. When leakage occurs all over a great region, as shown in this diagram, every portion of the region is polar; the word polar simply means that you have a place somewhere on the surface of the magnet where filings will stick on; and if filings will stick on to a considerable way down toward the middle all that region must be considered polar, though more strongly at some parts than at others. There are some cases where you can say that the polar distribution is such that the magnetism leaking through the surface acts as if there were a magnetic centre of gravity a little way down, not actually at the end; but cases where you can say there is such a distribution as to have a magnetic centre of gravity are strictly few. When Gauss had to make up his magnetic measurements of the earth, to describe the earth's magnetism, he found it absolutely impossible to assign ony definite centre of gravity to the observed distribution of magnetism over the northern regions of the earth; that, indeed, there was not in this sense any definite magnetic pole to the earth at all. Nor is there to our magnets. There is a polar region, but not a pole; and if there is no centre of gravity of the surface magnetism that you can call a pole from which to measure distance, how about the law of inverse squares? Allow me to show you an apparatus (fig. 27), the only one I ever heard of in which the

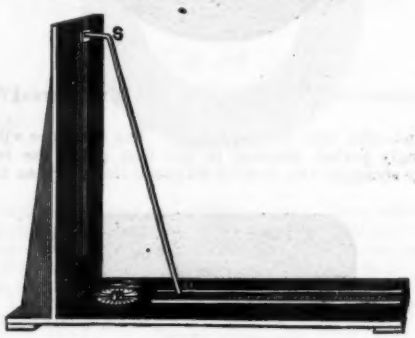


FIG 27.

APPARATUS TO ILLUSTRATE THE LAW OF INVERSE SQUARES.

law of inverse squares is true. Here is a very long thin magnet of steel, about 3 feet long, very carefully magnetised so as to have no leakage until quite close up to the end. The consequence is that for practical purposes you may treat this as a magnet having point poles, about an inch away from the ends. The south pole is upwards, and the north pole is below, resting in a groove in a base-board which is graduated with a scale, and is set in a direction east and west. I use a long magnet, and keep the south pole well away, so that it shall not perturb the action of the north pole, which, being small, I ask to be allowed to consider as a point. I am going to consider this point as acting on a small compass needle suspended over a card under this glass case constituting a little magneto-meter. If this were properly arranged in a room free from all other magnets, and set so that that needle shall point north, what will be the effect of having the north pole of the long magnet at some distance eastwards? It will repel the north end and attract the south, producing a certain deflection which we can read off; reckoning the force which causes it by calculating the tangent of the angle of the deflection. Now, let us move the north pole (regarded as a point) nearer or farther, and study the effect. Suppose we halve the distance from the pole to the indicating needle, the deflecting force at half the distance is four times as great; the force at double the distance is one quarter as great. Wherefore? Because, firstly, we have taken a case where the distance apart is very great compared with the size of the pole; secondly, the pole is practically concentrated at a point; thirdly, there is only one pole acting; and, fourthly, this magnet is of hard steel, and its magnetism in no way depends on the thing it is acting on, but is constant. I have carefully made such arrangements that the other pole shall be in the axis of rotation, so that its action on the needle shall have no horizontal component. The apparatus is so arranged that whatever the position of that north pole, the south pole, which merely slides perpendicularly up and down on a guide, is vertically over the needle, and therefore does not tend to turn it round in any direction whatever. With this apparatus one can approximately verify the law of inverse squares. But this is not like any electro-magnet ever used for any useful purpose. You do not make electro-magnets long and thin, with point poles a very large distance away from the place where they are to act; no, you use them with large surfaces close up to their armature.

There is yet another case which follows a law that is not a law of inverse squares. Suppose you take a bar magnet, not too long, and approach it broadside on towards a small compass needle, fig. 28. Of course, you know as soon as you get anywhere near the compass needle it turns round. Did you ever try whether the effect is inversely proportional to the square of the distance reckoned from the middle of the compass needle to the middle of the magnet? Do you think that the deflexions will vary inversely with the squares of the distances? You will find they do not. When you place the bar magnet like that, broadside on to the needle, the deflexions vary as the cube of the distance, not the square.

FIG. 28.

DEFLEXION OF NEEDLE CAUSED BY BAR MAGNET BROADSIDE ON.

Now, in the case of an electro-magnet pulling at its armature at a distance, it is utterly impossible to state the law in that misleading way. The pull of the electro-magnet on its armature is not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square root, nor to the three-halfth root, nor to any other power of the distance whatever, direct or inverse, because you find, as a matter of fact, that as the distance alters, something else alters too. If your poles were always of the same strength, if they did not act on one another, if they were not affected by the distance in between, then some such law might be stated. If we could always say, as we used to say in the old language, "at that pole," or "at that point," there are to be considered so many "units of magnetism," and at that other place so many units, and those are going to act on one another; then you could, if you wished, calculate the force by the law of inverse squares. But that does not correspond to anything in fact, because the poles are not points, and further, the quantity of magnetism on them is not a fixed quantity. As soon

FIG. 29.—CLOSED MAGNETIC CIRCUIT.

as the iron armature is brought near the pole of the electro-magnet, there is mutual interaction; more magnetic lines flow out from the pole than before, because it is easier for magnetic lines to flow through iron than through air. Let us consider a little more narrowly that which happens when a layer of air is introduced into the magnetic circuit of an electro-magnet. Here we have (fig. 29) a closed magnetic circuit, a ring of iron, uncut, such as that on which we experimented last week. The only reluctance in the path of the magnetic lines is that of the iron, and this reluctance we know to be small. Compare fig. 29 with fig. 30, which represents a divided ring with air gaps in between the severed ends. Now air is a less permeable medium for magnetic lines than iron is, or, in other words, it offers a greater magnetic reluctance. The magnetic permeability of iron varies as we know both with its quality and with the degree of magnetic saturation. Reference to Table III. shows that if the iron has been magnetised up so as to carry 16,000 magnetic lines per square centimetre, the permeability at that stage is about 320. Iron at that stage conducts magnetic lines 320 times better than air does: or air offers 320 times as much reluctance to magnetic lines as iron (at that stage) does. So then the reluctance in the gaps to magnetisation is 320 times as great as it would have been if the gaps had been filled up with iron. Therefore, if you have the same magnetising coil with the same

battery at work, the introduction of air-gaps into the magnetic circuit will, as a first effect, have the result of decreasing the number of magnetic lines that flow round the circuit. But this first effect itself produces a second effect. There are fewer magnetic lines going through the iron. Consequently, if there were 16,000 lines per square centimetre before there will now be fewer —say only 12,000 or so. Now refer back to Table III., and you will find that when B is 12,000 the permeability of the iron is not

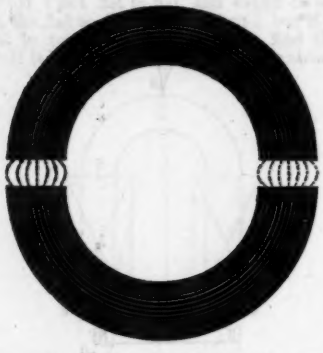


FIG. 30.—DIVIDED MAGNETIC CIRCUIT.

320 but 1,400 or so. That is to say, at this stage, when the magnetisation of the iron has been pushed only so far, the magnetic reluctance of air is 1,400 times greater than that of iron, so that there is a still greater relative throttling of the magnetic circuit by the reluctance so offered by the air-gaps.

Apply that to the case of an actual electro-magnet. Here is a diagram, fig. 31, representing a horseshoe electro-magnet with an armature of equal section in contact with it. The actual electro-magnet for the experiment is here on the table. You can calculate

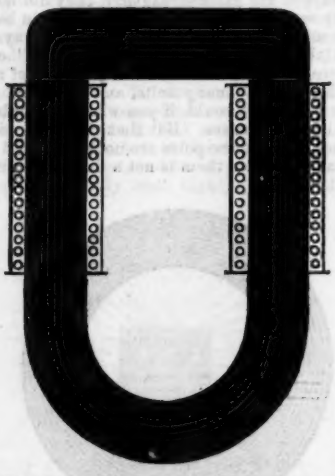


FIG. 31.—ELECTRO-MAGNET WITH ARMATURE IN CONTACT.

out from the section, the length of iron, and the table of permeability, how many ampère turns of excitation will produce any required pull. But now consider that same electro-magnet, as in fig. 32, with a small air gap between the armature and the polar faces. The same circulation of current will not now give you as much magnetism as before, because you have interposed air gaps; and by the very fact of putting in reluctance there the number of magnetic lines is reduced.

Try, if you like, to interpret this in the old way by the old notion of poles. The electro-magnet has two poles, and these excite induced poles in the opposite surface of the armature, resulting in attraction. If you double the distance from the pole to the iron, the magnetic force (always supposing the poles are mere points) will be one quarter, hence the induced pole on the armature will only be one quarter as strong. But the pole of the electro-magnet is itself weaker. How much weaker? The law of inverse squares does not give you the slightest clue to this all-important fact. If you cannot say how much weaker the primary pole is, neither can you say how much weaker the induced pole will be, for the latter depends upon the former. The law of inverse squares in a case like this is absolutely misleading.

Moreover, a third effect comes in. Not only do you cut down the magnetism by making an air-gap, but you have a new consideration to take into account. Because the magnetic lines, as they pass up through one of the air-gaps, along the armature down the air-gap at the other end, encounter a considerable reluctance, the whole of the magnetic lines will not go that way; a lot of them will take some shorter cut, although it may be all through air, and you will have some leakage across from limb to limb. I do not say you never have leakage under other circumstances: even with an armature in apparent contact there is always a certain amount of sideway leakage. It depends on the goodness of the contact. And if you widen the air-gaps still further, you will have still more reluctance in the path, and still less magnetism, and still more leakage. Fig. 33

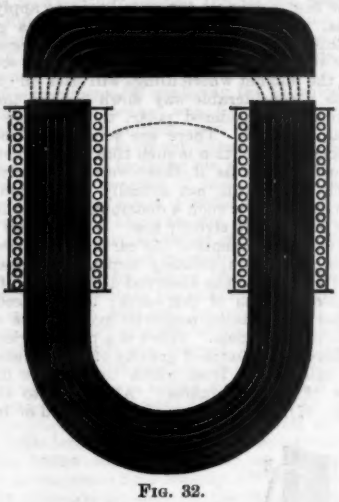


FIG. 32.

ELECTRO-MAGNET WITH AIR GAP ONE MILLIMETRE WIDE.

roughly indicates this further stage. The armature will be far less strongly pulled, because, in the first place, the increased reluctance strangles the flow of magnetic lines, so that there are

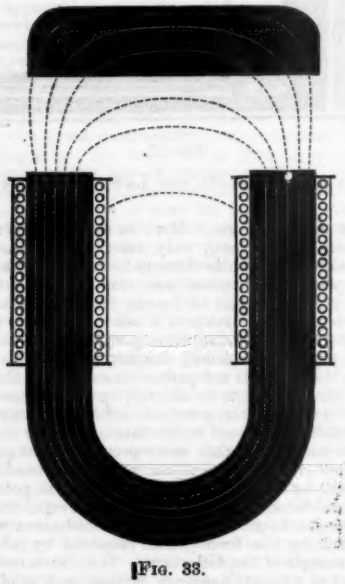


FIG. 33.

fewer of them in the magnetic circuit; and, in the second place, of this lesser number only a fraction reach the armature because of the increased leakage. When you take the armature entirely away, the only magnetic lines that go through the iron are those that flow by leakage across the air from the one limb to the other. This is roughly illustrated by fig. 34, the last of this set.

Leakage across from limb to limb is always a waste of the magnetic lines, so far as useful purposes are concerned. Therefore it is clear that, in order to study the effect of introducing the distance between the armature and the magnet, we have to take into account the leakage; and to calculate the leakage is no easy matter. There are so many considerations that occur as to that which one has to take into account that it is not easy to choose the right ones and leave the wrong ones. Calculations we must make by-and-bye—they will be added as an appendix to this lecture—but for the moment experiment seems to be the best guide.

I will, therefore, refer, by way of illustrating this question of leakage, to some experiments made by Sturgeon. Sturgeon had a long tubular electro-magnet made of a piece of old musket barrel of iron wound with a coil; he put a compass needle about a foot away, and observed the effect. He found the compass needle deflected about 23°; then he got a rod of iron of equal length, and put it in at the end, and found that putting it in so

that only the end was introduced—in the manner I am now illustrating to you on the table—the deflection increased from 23° to 37°; but when he pushed the iron right home into the gun barrel, it went back to nearly 23°. How do you account for that? He had unconsciously increased its facility for leakage when he lengthened out the iron core. And when he pushed the rod right home into the barrel, the extra leakage which was due to the

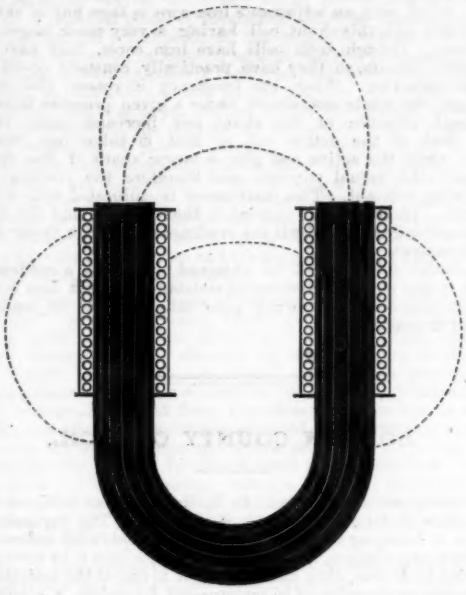


FIG. 34.

added surface could not and did not occur. There was additional cross section, but what of that? The additional cross section is practically of no account. You want to force the magnetism across some 20 inches of air which resists from 300 to 1,000 times as much as iron. What is the use of doubling the section of the iron? You want to reduce the air reluctance, and you have not reduced the air by putting a core into the tube.

(To be continued.)

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—LEEDS, 1890.

NOTES ON HIGH VACUA.

By J. SWINBURNE.

(Read before Section A, September 9th, 1890.)

I.

IN a series of papers on "Incandescent Lamp Manufacture," I called attention to the great superiority of the Geissler to the Sprengel form of mercury pump. Several kinds of Sprengel pump were successively connected to a Geissler, and both were worked at the same time. The Sprengel invariably stopped taking air down before the Geissler; in fact, the Geissler never stops. It acts as its own McLeod gauge, and never indicates a perfect vacuum. The probable reason why the merits of the Geissler have been so underrated is that it needs the greatest care in securing perfect dryness of the bulb and valve. Not only will traces of water vapour condense under the floating valve instead of lifting it and going through, but it is probable air does so too. About a century ago Davy showed that if the mercury were allowed to run up gently in an imperfect Torricellian vacuum, a bubble was left; but if allowed to rise suddenly, it indicated a perfect vacuum, the air being condensed against the glass. In the lamp papers I described a form of pump which avoids difficulties due to small condensations. The main bulb discharges into a small chamber sealed by a little V-tube, so that a pressure of 1/100 A would move the mercury. This chamber exhausts into a larger globe, exhausted mechanically, and sealed by a floating valve. The small chamber is thus as thoroughly exhausted as an ordinary pump can pump it; but the pump proper, exhausting into high vacuum, can thus work better. The condensed air and water cannot expand back into it. It is thus really a double pump, or two mercury pumps in series. The only drawback is that it needs some pressure to open the first valve or sealing, so that there might, after all, be some condensation under it. I have lately devised and used a pump made as follows:—A, is the body or chamber of the pump proper. This exhausts into the small chamber, B, sealed by the valve, C, and this exhausts into the chamber, G, sealed by the floating valve, H. G is connected to a reservoir and mechanical air pump. The valve, C, has a long thin glass rod passing down through A into the lower tube, which acts as a guide. A loose sleeve, F, is strung on this rod. There is a swelling at E which fits the lower end of the sleeve, and is small enough to pass through the neck in putting the pump together. When the mercury rises in the globe, A, it lifts the sleeve till the lower end catches on E, which closes it. The mercury rises, and floats the sleeve, thus lifting the valve, C. The mercury that sealed C, then runs out, and there is a clear passage through into B; so no condensation takes place in A. The mercury rises till it floats H. When it falls, the valve, C, acts again, for the mercury has filled the sleeve, F, over the top, and C is heavy enough to sink the sleeve and rod when the sleeve is full of mercury. I have tried electromagnetic and other arrangements; but this is the best, as far as I have gone.

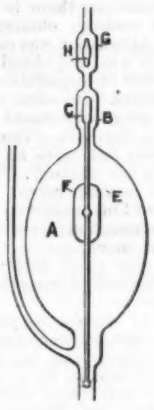


FIG. 1.

FIG. 2

When using a pump it is best not to let air, and perhaps moisture, run through it more than can be helped. By the use of a sort of syphon it is possible to seal on new work to be exhausted without letting the air pressure into the pump.

The point, K, is the barometric height at which the mercury normally stands in the tube, R. There is then a clear passage between L, which is connected to the tubes to be exhausted, and M, which goes to the drying tubes and pump. When a tube has been sealed off and a new one is to be put on, the mercury reservoir at the foot of the arrangement is raised so that bulb, N, is filled. A tap at the foot of the tube, R, is closed, and the vacuum in L is broken. The mercury then runs up to the new barometric height, P. The new tube is then sealed on and exhausted by a mechanical pump, the connection being then sealed off. The mercury in the long tube then stands only half an inch or so above that in N, and on opening the tap at the foot of R, the communication is made again to the pump. The small bulb, O, and the trap at the top are to prevent a plug of mercury from going round into the phosphoric tubes.

The pump is driven by water so as to be self-acting, and can be left running for any length of time. Those who have worked much with mercury pumps will realise the value of this. Nothing makes one feel the futility of life more than to exhaust something by hand which cracks at the last stage, when five hours of life have been ticked off.

II.

In the same papers on lamp making I urged that the methods of measuring high vacua were inaccurate and completely misleading. The McLeod gauge and the induction coil are usually relied on for testing vacua. In incandescent lamp work the induction coil is almost exclusively used. With the test by induction sparks, I have, at present, nothing new to add, and will confine myself to the McLeod gauge. In measuring vacua with this gauge it is assumed that the mercury itself has no vapour tension. The vapour tension of mercury has been given by Regnault as about 50 millionths of an atmosphere. If it is anything like this, of course a vacuum of one millionth, or of ·005 millionth, as some experimenters profess to have reached, is absurd. When discussing this subject at the Society of Arts after Dr. S. P. Thompson's well-known paper on "Mercury Pumps," Prof. Ramsay gave ·25 millionth of an atmosphere, or, as I shall write it shortly, ·25 m., as the vapour tension of mercury at ordinary temperatures.

The whole action of a pump is consistent with a vapour tension of from 25 m. to 50 m. A Geissler does not reduce the pressure in geometrical progression; but when it gets a good vacuum it takes out very little air each stroke, worked fast, and much more if worked slowly. This looks as if when the tension of mercury vapour was nearly reached, the air taken out at each stroke was what diffused into the mercury vapour. This would also explain why a Geissler, which goes on long after Sprengel stops, does not so readily make a sparkless tube. A Sprengel stirs up the mercury, and gives the tube being exhausted more chances of getting filled with mercury vapour, which is a non-conductor. This also explains why so many experimenters get better vacua with hot mercury. Of course a new pump should be heated to get the moisture off the glass, but not when it is in ordinary use.

To test this more directly, I attached two McLeod gauges to the same pump. They communicated till a fair vacuum was reached. One was then sealed by raising the mercury past the elbow tube. The gauges were allowed to communicate by lowering the mercury every now and then, and it was always lowered before taking a reading. By this arrangement, when the pressure was reduced nearly to the vapour pressure of mercury, one gauge might have little but mercury vapour, and show a good vacuum; while the other had air at the same pressure, and showed a pressure equal to the vapour tension of mercury, or nearly so. The gauges are graduated by finding $p\ v$ corresponding to one millionth of an atmosphere, and graduating accordingly. The pressure in millionths is then the product of the reading on the closed tube and the difference in the column. Each reading is thus readily taken at several pressures to make sure there is no condensation of any vapours or gases. The readings obtained varied in an extraordinary way. When the exhaustion was carried so far that the open gauge registered 2 m. or 3 m., the closed registered from 20 m. to 60 m. The least difference in temperature seems to make a large difference in the readings. In some cases, when the vacuum was still low, the open gauge was heated till the mercury sputtered, and condensed about the bulb. The bulb was then warmed to evaporate the mercury and drive all the air out, and the elbow tube sealed by raising the mercury. When the gauge was cool both were unsealed and readings taken. The gauge that had been warmed sometimes gave 1 m. against no less than 230 m. in the other. Ten minutes' connection generally brought the readings equal. Obviously the movement of the air need not depend on diffusion only; for a very small difference of temperature would cause mercury to evaporate in one gauge and condense in the other, driving the air with it.

I made a gauge with an alloy of about equal parts of potassium and sodium, which is liquid at ordinary temperatures. It would, of course, absorb any mercury vapour, and has probably a low vapour tension. It was very troublesome, for it could not be exposed to the air for a moment, and heavy hydrocarbons would prevent the pump's working. The alloy always gets some moisture, and gets coated with a thin film of oxide which prevents drops from uniting, and they can only be run together by heating under a hydrocarbon of low boiling point. I eventually got the gauge fitted up, but the alloy acted on the film of moisture on the glass, and the bubbles formed seemed to drive plugs of it about. It has a very low specific gravity, and pistons of it began to stray about inside the pump, and I was afraid they might get to the mercury, and by combining explosively, smash the pump, so the experiment was abandoned. In one experiment a plug did wander into the tube, R, and cracked it.

Fusible alloy was next tried. It worked better, but the vapours of some sulphur that was used to trap any mercury vapour blackened the surface, and only two readings were obtained These gave a pressure of only 13·5 m. as the vapour tension of mercury.

Whether it is really 13 m. or 50 m. is of comparatively little importance; but there seems to be quite enough evidence that the readings of ·01 m., and higher vacua that have been given, are inaccurate to the extent of some hundreds of thousands per cent. This is important in many investigations pursued by means of mercury pumps, for instance, experiments on the "Fourth State of Matter." The question is also important in lamp making, as it shows that better vacua are possible, and they may be an advantage. I do not know whether pumps worked with alloy of sodium and potassium will come into commercial use.

DISCUSSION.

Lord RAYLEIGH considered the points that Mr. Swinburne had brought before the Section were of great interest. He had not had much experience in obtaining the highest vacua, but he had a good deal of experience with the mercury pump. He had been astonished with the immense quantity of vapour which hung about. At one time he passed a large quantity of air slowly over the mercury and then through a sulphur tube, and it would astonish most people to see what the discolouration of the sulphur was from the mercury vapour carried over the area. The points as to the behaviour of the M'Leod gauge as the only available method for measuring the vacua were of the highest importance, and in conclusion he hoped Mr. Swinburne would not slacken his efforts to arrive at the bottom of the matter.

THE COMPENSATION OF ALTERNATING-CURRENT VOLTMETERS.

BY J. SWINBURNE.

(Read before Section A, September 9th, 1890.)

IN 1887 I had the honour of bringing before this Section several methods of compensating voltmeters and resistance-bridges for variations of temperature. Wires with different temperature co-efficients were used, by which means errors from change of temperature can be avoided. Methods of compensating wattmeters for the errors inherent in them were also explained. The present communication relates to a somewhat analogous arrangement for compensating alternating voltmeters for changes of frequency.

It is much more easy to make a current indicator for alternating than direct currents, for troubles from hysteresis do not come in, and the slight tremble makes the moving part hang freely. If it is attempted, however, to use such a instrument as a voltmeter, the self-induction makes the reading far too low, and the error varies with the frequency.

To get over this trouble, a voltmeter may have a non-inductive, or nearly non-inductive, resistance put in shunt to its active coil. A coil with an adjustable iron core is then put in shunt to the active coil, this shunt coil having a very much larger time-constant. Though both coils have iron cores, they have open magnetic circuits, so they have practically constant co-efficients of self-induction. When the frequency increases, the current through the whole instrument under a given pressure falls; but the back pressure of the shunt coil increases more rapidly than that of the active coil, so that it takes less than its share, while the active coil gets a larger share of the reduced current; the actual current, and therefore the reading, in it remaining constant. The instrument is calibrated with a direct current. An alternating current is then put on, and the core of the shunt coil regulated till the readings agree with those of the direct current.

A similar effect might be obtained by putting a condenser in shunt to the non-inductive series resistance; but it does not look so promising, and I have not gone into the size of condenser needed in practice.

LONDON COUNTY COUNCIL.

THE weekly meeting was held at Spring Gardens, S.W., on Tuesday last, with Sir John Lubbock in the chair. The Asylums Committee, in bringing forward their report, stated, with reference to the Claybury Asylum, it had been decided to light it by electricity. In order to do this, they had referred it to one of the assistants in the engineers department to prepare and formulate a scheme for that object. It would be necessary for the purpose to expend a sum of money for the preparation of plans, the employment of temporary draughtsmen, and, possibly, for consultation with an expert. In conclusion, the committee recommended that a certain sum of money should be devoted to the object.

NEW PATENTS—1890.

15413. "An arc electric lamp." T. B. GRANT. Dated September 29.

15455. "Improvements in or appertaining to welding metals electrically." W. P. THOMPSON. (Communicated by C. L. Coffin, United States.) Dated September 30. (*Complete.*)

15456. "Improvements in or appertaining to welding metals electrically." W. P. THOMPSON. (Communicated by C. L. Coffin, United States." Dated September 30. (*Complete.*)

15464. "Apparatus for governing electric light engines, marine engines, and other engines." T. SULLIVAN, J. W. HUGHES, V. W. CHEMERY, and A. H. S. BROWNE. Dated September 30.

15469. "Improved method of, and apparatus for, administering electricity to the human body." O. IMRAY. (Communicated by the Bethel Electric Medical Baths Company, Limited, Australia.) Dated September 30. (*Complete.*)

15482. "Improvements in and relating to electric batteries." H. H. LAKE. (Communicated by the Crosby Electric Company, United States.) Dated September 30. (*Complete.*)

15547. "Improvements in locked switches for electric current circuits." J. A. ILIFFE and F. TEAGUE. Dated October 1.

15573. "An improved method and means of attaching and suspending electric and other fittings." F. J. DOWN. Dated October 2.

15629. "Improvements in telephone transmitters and induction coils to be used therewith, and for other purposes." W. WHEATLEY and J. LEWIS. Dated October 2.

15640. "Improvements in electric or secondary batteries." E. HANCOCK and A. J. MARQUAND. Dated October 2.

15643. "Improvements in and connected with electric tramways or railways, and for working electrically propelled vehicles thereon." E. HOPKINSON. Dated October 2.

15644. "Improvements in electric clock-circuit-closing apparatus." W. BROWN. Dated October 2.

15654. "Improvements in pull-down switches for walls or ceilings for electric light." C. W. COX and F. ROBINSON. Dated October 3.

15741. "Electric fire indicator." T. R. DOUSE. Dated October 4.

ABSTRACTS OF PUBLISHED SPECIFICATIONS 1889

10640. "Improvements in electric arc lamps." T. P. C CRAMPTON and A. ESSINGER. Dated July 1. 8d. Claims:—1. In combination with the lower carbon holder tube, a crown piece at its top carrying several refractory studs, and a weight urging upwards a canoidal piece of insulating material supporting the carbon, so that the coned point of the carbon is retained in position as it is consumed by bearing against the studs, against which the conoidal insulating piece is made to bear when the carbon is exhausted, substantially as and for the purpose set forth. 2. In combination with the upper carbon holder tube having attached to it a core subject to the differential attraction of two solenoids, a clutch consisting of jaws which grip the carbon until, by the descent of the tube a certain distance, they meet adjustable stops whereby they are released, allowing the carbon to slip downwards, substantially as described. 3. The combination of a lower carbon holder such as is referred to in the first claim, and of an upper carbon holder and clutch such as is referred to in the second claim with suitable solenoids and framing, constituting an electric arc lamp, substantially as described.

12185. "An improved mode of and apparatus for distributing electricity." A. H. HOWARD. Dated July 31. 11d. Claims:—1. In a system of electric distribution from a central station, through storage batteries situated at various points on the external circuit, the use, at the central station, of a periodically acting automatic switching apparatus, for diverting (temporarily) the entire dynamo current from the batteries in charge, to a resistance, and allowing mechanism situated at the various storage stations on the line, to come into action and effect the changes in the local circuits, as and for the purpose above described. 2. In combination with the storage batteries at each installation, a rotary commutator arranged to effect a cycle of changes in the connection of the batteries with the line wire, and with each other, as and for the purpose above set forth.

12236. "Improvements in appliances for distribution of power by alternating and commutated electric currents." J. SWINBURNE. Dated August 1. 8d. Transformers are used to transform alternating currents, and these alternating currents are, when desired, combined to form direct currents, and may themselves be produced by the commutation of direct currents. 5 claims.

12237. "Improvements in and connected with electric transformers." J. SWINBURNE. Dated August 1. 8d. Two or more transformers are used for each house, and are put into or out of circuit by automatic gear as required. Thus a 100-lamp house may have a 90 and a 10-lamp transformer. The 10-lamp transformer is ordinarily in circuit, but when the current rises to that of 11 lamps, an electro-magnet or other suitable mechanism cuts the primary and secondary of the 90-light transformer into circuit. When no lamp is used the mechanism may be arranged to cut out even the 10-lighter, and leave in a minute transformer just big enough to work the mechanism. 5 claims.

12503. "Improvements in dynamo-electric machines." F. V. ANDERSEN. Dated August 7. 8d. Has for its objects to construct the brushes by which the current is taken off or conducted to a dynamo-electric machine of an improved shape and in an improved manner. The brushes are constructed in the shape of an arc of a circle, and are manufactured by winding copper or other wire, or conducting strips or tape, into a round reel, and soldering the wire or strips or tapes together at as many places as the number of brushes intended to be cut out of the reel, and, finally, cutting the reel into the intended number of pieces, so that a soldered portion is at or near one end of each piece, and the other end is unsoldered. The brushes are arranged in such manner that the end that comes in contact with the commutator is radial to it. 4 claims.

13553. "Improvements in and in connection with electrical signalling apparatus for preventing collisions between trains on railways." E. EDWARDS. (A communication from abroad by T. Verls, of Würzburg.) Dated August 27. 8d. This invention has for its object the prevention of collisions between locomotive engines or trains travelling in the same or opposite directions upon the same line of rails, and also to give notice at the right time of the threatening danger to the drivers of both locomotives by means of electrical bells. 3 claims.

CORRESPONDENCE.

Electricity Meters.

In your last week's issue under "Meters" in your Notes, I see with much interest that there are 515 electricity meters in use at the Geneva Central Station.

Permit me to say with regard to your concluding remark that I do not think it in the least doubtful that this total is largely exceeded in the London central stations. This company alone, for instance, has 206 electricity meters in daily operation, all of the Aron type, with one exception, and over 17,500 lights.

The Kensington and Knightsbridge Company, St. James's and Pall Mall, Westminster Company, and others will at least make the total reach 1,000, and to this would have to be added the meters on the alternating systems.

W. Howard Tasker,
Electrician Chelsea Electricity Supply Company, Limited.

October 21st, 1890.

In the last issue of your esteemed paper, on page 463, you mention under the heading "Meters," that 450 Aubert meters and 65 Aron meters are in operation at the Geneva Central Station. You conclude the leaderette with the question, "*We wonder whether London with all its central stations can total* 515 *meters in use?*"

Will you allow us to draw your attention to the fact that the Aubert meter is not an electricity meter like the Aron meter, but simply a primitive arrangement for counting the "lamp hours," consequently it does not come up to the standard which is expected in this country for meters.

As regards the number of meters in use in London, we cannot say positively how many meters of the various types are in actual use, but it may interest you to know as a positive fact that we have sold the following number of Aron meters:—

For the year	1887	26
" "	1888	69
" "	1889	354
" "	1890 up to date	721

And we have booked orders within the month of October for close on 1,100 Aron meters to be delivered during the coming season, most of which are for London.

The General Electric Company, Limited.
H. HIRST, *Director.*

The Lane-Fox Patents.

Now that "The Lane-Fox Electrical Company" is showing some fresh signs of vitality by bombarding the unfortunate "consumers" of electric light with mysterious manifestoes, threats of writs, *et hoc genus omne*, it would be useful, I think, if some of your more initiated readers would throw a little light upon this matter. Many good people, I fancy, have either forgotten Mr. Lane-Fox and his inventions, or are now hearing of them for the first time. Upon such minds the question "What is the Lane-Fox system?" has very much the some effect as the old riddle, "Who's Griffiths?" with which in my early youth the walls and hoardings of London used to be placarded. Is Mr. Lane-Fox also the Safe Man?

Mystified.

October 22nd, 1890.

Running Alternators Parallel.

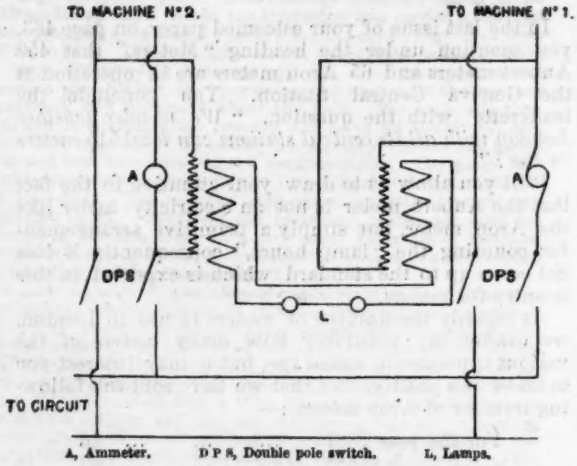
It may interest your readers to know that during the past few days we have tried running the Mordey alternators here in parallel. The results have been in every way satisfactory.

As we had no synchroniser, we joined a transformer to each of the two machines, and put the secondaries in series with two incandescent lamps, so that when the two machines were in phase, the lamps were bright as with an ordinary synchroniser. We tested the transformers for this by so connecting them both to one machine, that the lamps in series were bright with the secondaries in series. We then transferred the primary wires of one transformer, so as to connect it to the corresponding poles of the other machine,

We send you sketch of the connections. From these you will see that any current passing from one machine to the other is registered on both ammeters.

The machines were first put parallel when the load on the one supplying current to the outside circuits was only 5 ampères. They went into step at once and kept so. The current going between the machines to keep them in phase was not sufficient to make the needles swing more than 2 ampère divisions on the ammeters.

The load was transferred to either machine quite easily by speeding its engine up slightly by means of its governor.



A, Ammeter. D P S, Double pole switch. L, Lamps.

The second dynamo was switched out of and into circuit several times as the current increased. They were run parallel till after the heavy load of the evening (about 40 ampères) was passed, each machine taking half the work.

During the heavier loads, the swing of the needles was greater, showing that more current was being sent between the machines; but this would correspond to only 3 or 4 ampères.

When the load dropped under 30 ampères, the load was transferred to one dynamo, and the other switched out of circuit.

We have also made the experiment of switching the machines in parallel when not at the same voltage. The difference was about 3 per cent. The current which flowed between them was 10 ampères. This seems to indicate that a very large current indeed must have passed when Mr. Mordey made his experiment of putting a machine at 1,000 volts in parallel with one at 2,000 volts.

George S. Hooker, *Electrician.*

Bath Electric Light Works,
October 15*th*, 1890.

Accumulator Management.

Will Mr. Barber-Starkey kindly oblige by letting me know how much soda (common washing, I believe) should be put to one gallon of solution—1 to 10 for accumulators. I have lately bought some second-hand cells. Some give a good current after charging and others comparatively little, though all look much the same in colour. What is likely to be wrong, and how can I remedy it?

I have already tried some soda, adding it to the solution, which hissed up until it was dissolved; but considerable sulphate still remains.

B. B.

Telephonic Specific Inductive Capacity.

In an article under the above heading in your last issue, Mr. W. W. Jacques points out that there is a considerable difference between the telephonic and the telegraphic specific inductive capacity of certain materials.

After describing some experiments made by himself and others upon various dielectrics, he gives a table showing that the telephonic capacity of all the samples tried, except one, is HIGHER than the telegraphic capacity of those samples.

Surely this is not quite correct.

All theory and practice, except Mr. Jacques's, so far as I am aware, tend to show that the capacity of any dielectric is LESS when measured by currents of short duration—*e.g.*, telephonic currents—than when measured by currents of longer duration, *e.g.*, telegraphic currents, owing to the "absorption effect" noticeable when any dielectric is charged for an appreciable time.

This is clearly explained in most text-books upon the subject, and is noticed even in the authority quoted by Mr. Jacques, viz., "Gordon's Electricity and Magnetism," chapter 11. On pages 99 and 103 of the second edition, experiments are described and figures given which clearly show that Mr. Jacques's deductions are not correct.

Again, on page 109, we read: "*The capacity increases if the electrification is continued*—at first rapidly, then more slowly," &c.

As the question is of considerable importance in long distance telephony, and, as an earlier edition of the same article has been published in your Journal of 21st March last, page 314, without any one drawing attention to the inaccuracy of the results contained therein, I think an explanation is due from Mr. Jacques as to how his experiments were made, and also as to how he arrives at the "calculated results" given in the middle column of the table referred to.

J. W. Ullett.

October 21*st*, 1890.

On 28th March last you were good enough to publish a letter from me on the subject of telephonic specific inductive capacity, and in your Editorial columns you remarked that when Dr. Jacques had read the letter you would probably receive a disclaimer from him. The article by Dr. Jacques quoted in your last week's number from the New York *Electrical Engineer* is mainly a republication of the communication which I criticised, but with the omissions I claimed should be made. It seems to me that the article contains internal evidence that Dr. Jacques has read my letter, but I have not noticed any disclaimer in your columns.

Perhaps another reminder would bring it about.

J. E. Kingsbury.

October 21*st*, 1890.

Accumulator Explosions.

Having read the account of the extraordinary accident which took place on board Earl Poulett's steam yacht, the *Pathfinder*, I think the occurrence, though fortunately uncommon, may be easily accounted for on the supposition that during the violent storm of rain when the leak was reported, water must have collected somewhere near the main conductors, or some uninsulated portion of the system, and have been decomposed, liberating hydrogen; and a sufficient quantity of this gas, in conjunction with the atmospheric air would naturally and immediately explode on a light being struck. Therefore this mishap need in no way be attributed to the use of accumulators, as it seems they were properly ventilated, and such accidents may be readily prevented by taking care to duly protect and insulate the flow and return conductors, and other exposed portions of the system from each other.

H. Edmunds.

October 21*st*, 1890.